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Jacobs Engineering Group, Inc.
Pasadena, CA

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Appendix B - Procedures for Ambient Air Monitoring
Appendix C - Environmental Monitoring Activities--Past, Present and Proposed
Appendix D - Applicable Federal, State and Local Legislation, Standards and Regulations
Appendix E - Quality Assurance Bibliography
Appendix F - Federal and State Permits Required for Operation of an Oil Shale Facility

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Volume 2. Appendices

by

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ABSTRACT

Oil shale deposits in the United States are among the richest and most extensive in the world. Total identified resources of medium and rich shales in the United States are estimated at 2 trillion equivalent barrels of oil. About 600 billion barrels is considered recoverable with present technology. This report summarizes the anticipated EPA regulatory approach toward oil shale development and is designed to serve as a reference and guide to EPA offices, Federal agencies, and private developers involved with the emerging oil shale industry.

The report consists of two volumes. Volume 1 conveys EPA's understanding and perspective of oil shale development by providing (1) a summation of available information on oil shale resources; (2) a summary of major air, water, solid waste, health, and other environmental impacts; (3) an analysis of applicable pollution control technology, including limitations; (4) a guide for the sampling, analysis, and monitoring of emissions, effluents, and solid wastes from oil shale processes; (5) suggestions for interim objectives for emissions, effluents, and solid waste disposal, and (6) a summary of oil shale technology, emissions, and effluents. The report provides a brief yet thorough discussion of the environmental problems of oil shale development.

Volume 2 contains six appendices: State-of-the-Art of Oil Shale Development; Procedures for Ambient Air Monitoring; Past, Present, and Future Monitoring Activities; Applicable Federal, State, and Local Laws and Regulations; List of Analytical Procedures Manuals and Quality Assurance Manuals; and Catalog of Existing Federal, State, and Locally Required Permits.

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ABBREVIATIONS

AAS — atomic absorption spectroscopy
ANSI — American National Standards Institute
AOSS — Area Oil Shale Supervisor
API — American Petroleum Institute
ARCO — Atlantic Richfield Company
ASTM — American Society for Testing Materials
BACT — best available control technology
BAP — benzo(α)pyrene
BAT — best available technology
BCT — best control technology
BLM — Bureau of Land Management
BOD — biochemical oxygen demand
BPD — barrels per day
bpi — bytes per inch
BPSD — barrels per stream day
BPT — best practicable technology
BTU — British thermal units
cal — calorie
CDM — Camp Dresser & McKee Inc.
CDO — colony development operation
CDOW — Colorado Department of Wildlife
CFR — Code of Federal Regulations
cfs — cubic feet per second
COD — chemical oxygen demand
COS — carbonyl sulfides
CRS — Colorado Revised Statute
DDP — detailed development plan
DO — dissolved oxygen
DOC — dissolved oxygen content
DOE — Department of Energy
DOI — Department of the Interior
EC — electrical conductivity
EDF — Environmental Defense Fund
EDTA — ethylene-diamine tetraacetic acid
EDXRF — energy dispersive x-ray fluorescence spectroscopy
EIS — environmental impact study
EMP — environmental monitoring program
EPA — Environmental Protection Agency
ERDA — Energy Research and Development Administration
FID — flame ionization detector
FWPCA — Federal Water Pollution Control Act
GC/MS — gas chromatograph/mass spectrometer

GPM — gallons per minute
GPT — gallons per ton
ha — hectare
HC — hydrocarbons
IERL — Industrial Environmental Research Laboratory
in situ — in the original location
J.T.U.'s — Jackson Turbidity
kcal — kilocalorie
kmph — kilometers per hour
LETC — Laramie Energy Technology Center
LHD — load haul dump
mb — millibars
MDP — modular development phase
MDPMP — modular development phase monitoring program
MIS — modified in situ
MMC — Multi Mineral Corp.
mph — miles per hour
MST — Mountain Standard Time
MTB — methylthymol blue
NAAQS — National Ambient Air Quality Standards
NAS — National Academy of Sciences
NBS — National Bureau of Standards
NDIR — nondispersive infrared
NMHC — nonmethane hydrocarbons
NOIC — National Organization of Instrument Certification
NOx — oxides of nitrogen
NPDES — National Pollutant Discharge Elimination System
NSPS — New Source Performance Standards
NWS — National Weather Service
ORNL — Oak Ridge National Laboratory
OSHA — Occupational Safety and Health Administration
OXY — Occidental Oil Shale, Inc.
PAH — polycyclic or polynuclear aromatic hydrocarbons
pcf — pounds per cubic foot
pCi — picocurie
PIXE — particle-induced x-ray emission
POM — polycyclic organic matter
ppb — parts per billion
ppm — parts per million
ppt — parts per thousand
PSD — prevention of significant deterioration
PSIG — pounds per square inch (mercury scale)
RBOSC — Rio Blanco Oil Shale Company
RBOSP — Rio Blanco Oil Shale Project
RCRA — Resource Conservation and Recovery Act
SAR — Sodium Absorption Ratio
SCF — standard cubic foot
SCFD — standard cubic feet per day
SCMD — standard cubic meters per day
SCS — Soil Conservation Service
SGR — steam gas recirculation
SLM — sound level meter

SRM	— Standard Reference Material
SSU	— Saybolt seconds universal
TC	— total carbon
TCM	— tetrachloromercurate
TDS	— total dissolved solids
TFE	— tetrafluoroethylene
THC	— total hydrocarbons
TIC	— total inorganic carbon
TKN	— total kjeldahl nitrogen
TLC	— thin layer chromatography
TOSCO	— The Oil Shale Corp.
TPD	— tons per day
TPSD	— tons per steam day
TPY	— tons per year
TRW	— Thompson-Raymo-Woolridge
TSP	— total suspended particulates
TSS	— Total Suspended Solids
USBM	— U.S. Bureau of Mines
USGS	— U.S. Geological Survey
uv	— ultraviolet
VTN	— Voorheis-Trindle-Nelson
WRSP	— White River Shale Project

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APPENDIX A

STATUS AND DEVELOPMENT PLANS OF THE OIL SHALE INDUSTRY

Seven separate proposals currently exist to construct large-scale oil shale retorting plants, with the intent to develop a commercial project. Three of these projects are located on property leased from the U.S. Government under the provisions of the Prototype Oil Shale Leasing Program, three are to be located on private property, and one is on State leases. The projects are as follows:

- Rio Blanco Oil Shale Company
  - Federal Lease Tract C-a in Colorado
- Cathedral Bluffs Shale Oil Co.
  - Federal Lease Tract C-b in Colorado
- White River Shale Project
  - Federal Lease Tracts U-a and U-b in Utah
- Colony Development Operation
  - Private land in Colorado
- Union Oil Co.
  - Private land in Colorado
- The Superior Oil Co.
  - Private land in Colorado
- TOSCO Corp.
  - State leases in Utah

The proposed Rio Blanco project would employ a modified in situ recovery process and would include a 10-year Modular Development Phase followed by a 30-year Commercial Development Phase at a capacity of 10,300 tonnes/day (76,000 bbl/day). The proposed C-b project would use a modified in situ recovery process currently being developed by Occidental Oil Shale, Inc. on private property in Colorado. Development of Tract C-b would involve construction of a small retort test area, which would begin operations while development of the 7,800-tonne/day (57,000 bbl/day) commercial operation was proceeding.

The proposal by White River Shale Project would include a modular development approach leading to a 13,600-tonne/day (100,000-bbl/day) commercial operation on Federal Tracts U-a and U-b in Utah. Initial plans call for retorting to be conducted in both direct and indirect-heated aboveground retorts. Surface retorting would also be used in the commercial project proposed by the Colony

Development Operation. A 6,400-tonne/day (47,000-bbl/day) project has been proposed using TOSCO II retorting. Union Oil's project would employ a 1,224-tonne/day (9,000-bbl/day) retort of the firm's own design. Superior Oil's commercial multi-mineral recovery project would use a circular grate retorting process developed by Superior and would have a capacity of 18,100 tonnes/day (24,000 tons/day) of oil shale. TOSCO plans to use its TOSCO II retorting technology and underground mining on the Sand Wash project; the commercial plant, as proposed, would include six 9,980-tonne/day (11,000-ton/day) retort modules.

A summary of the schedules for these projects is shown in Figure A-1. Several companies (Union, Superior, Paraho, TOSCO, Lurgi) are conducting continuing studies (on proprietary bases) concerning aboveground retorting. In addition to these surface retorting studies, true or modified in situ development programs are being conducted by Occidental, Geokinetics, Equity, Dow Chemical, and the U.S. Department of Energy (DOE) Laramie Energy Technology Center, and Multi Mineral Corp.

Occidental Oil Shale, Inc. currently has a cost-sharing contract with the DOE to develop and demonstrate the technical feasibility of the company's vertical modified in situ recovery process. Successful results from these field tests would serve as the basis for modular large-scale development using the process on Federal Tract C-b. Geokinetics, Inc., also has a cost-sharing contract with DOE to develop an in situ recovery process. This technique would involve high-explosive fragmentation of shallow deposits followed by true in situ retorting with a horizontally moving fire front.

The project being conducted by Equity Oil Co. in Colorado is designed to evaluate the feasibility of injecting superheated steam into the leached oil shale zone in the Piceance Creek Basin to retort the oil shale in situ. Funding is being provided through a cooperative agreement with DOE.

The Dow Chemical Co. has a contract with DOE to conduct a program to test in situ processing of Michigan Antrim shale. Conventional fracturing, propping, and leaching techniques will be employed, followed by horizontal in situ retorting. The Laramie Energy Technology Center has been conducting field tests in true in situ production of shale oil since 1966. Current tests involve a combination of steam and air injection at the Wyoming test site near Rock Springs. Future testing will concentrate on determining methods for producing sufficient porosity and permeability for true in situ retorting.

A summary of the project schedules for these field tests is shown in Figure A-2.

RIO BLANCO OIL SHALE COMPANY

Gulf Oil Corp. and Standard Oil Co. (Indiana) submitted the high bonus bid for Tract C-a ($210 million) on January 8, 1974, at the first lease sale under the Federal Prototype Oil Shale Leasing Program. The lease became effective on March 1, 1974. In March 1976, Rio Blanco Oil Shale Project, the joint venture formed by Gulf and Standard for the purpose of developing the tract, submitted a Detailed Development Plan (DDP) which called for open pit mining and surface retorting of the oil shale reserves. Shortly thereafter, a one-year lease suspension was obtained

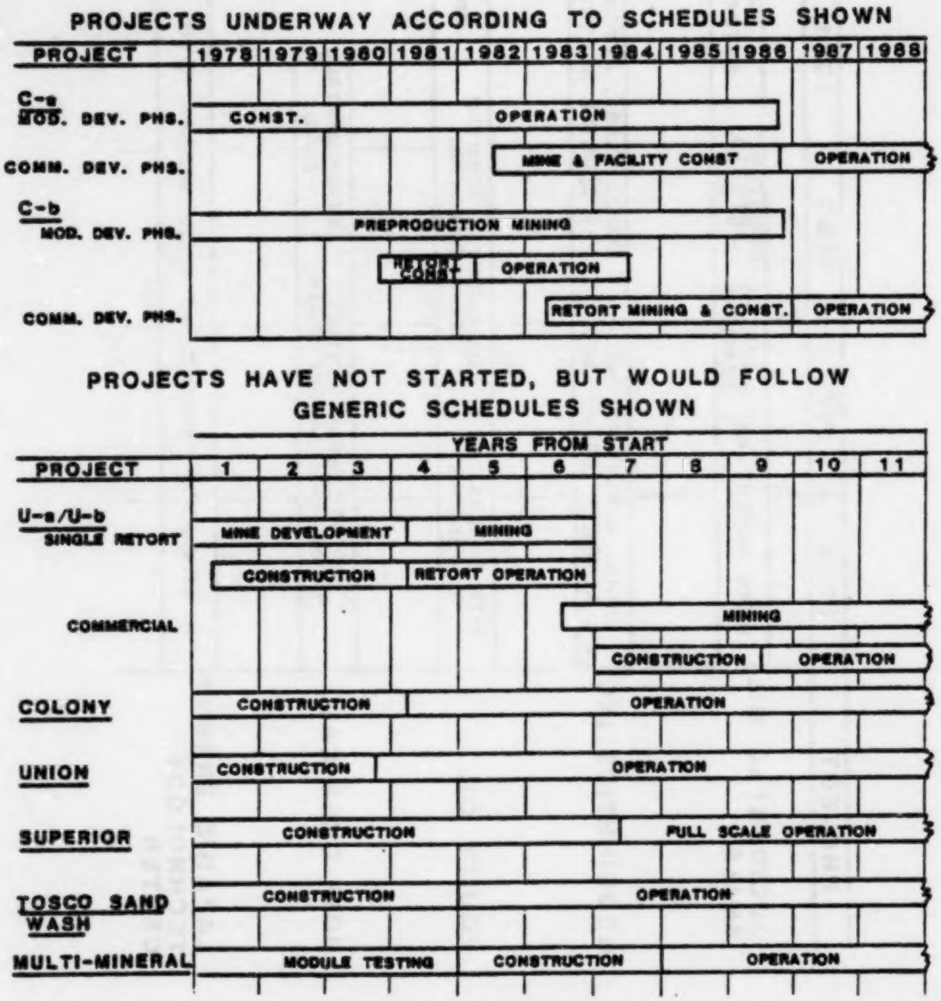


Figure A - 1. Project schedules for commercial oil shale projects.

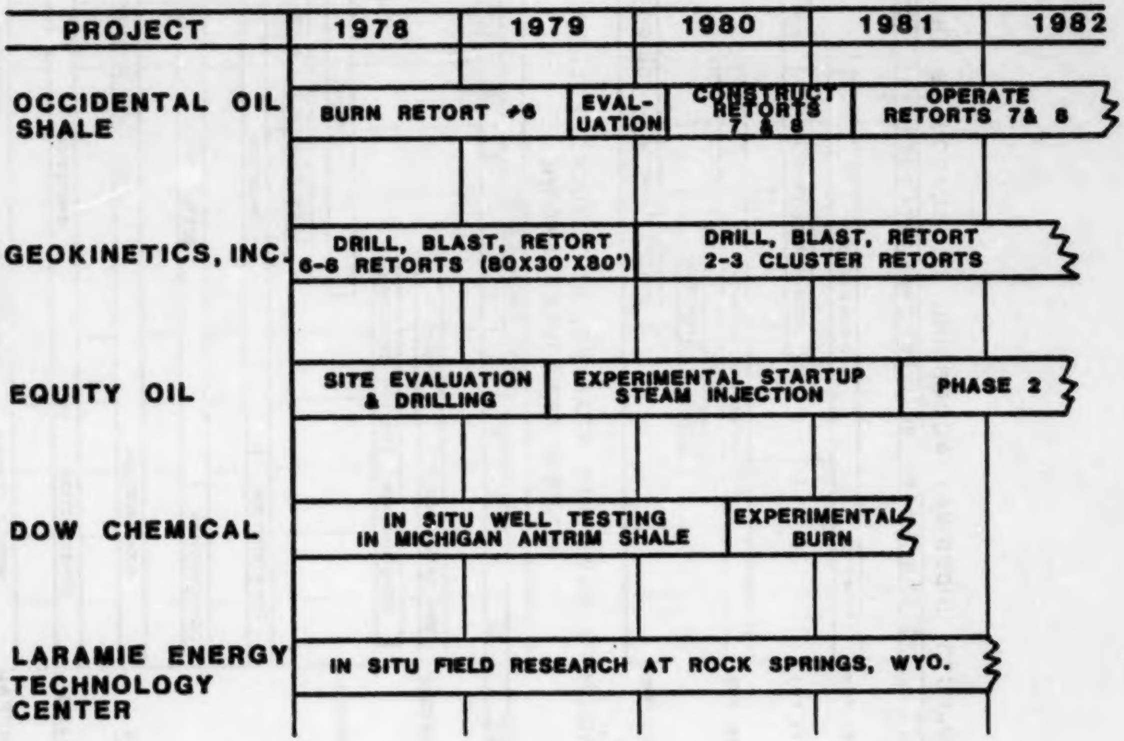


Figure A - 2. Project schedules for field tests of oil shale projects.

because of a number of environmental and operational considerations. DDP modifications in May 1977 and August 1979, have resulted in the current plan which includes a 10-year Modular Development Phase (MDP) to perfect modified in situ retorting technology with at least three retorts to be developed and burned through 1981 (1,2,3). This phase would be followed by a 30-year Commercial Development Phase at a planned capacity of 10,340 tonnes/day (76,000 bbl/day).

Since Rio Blanco intends to use a vertical modified in situ (MIS) retorting technology which has not been proved in the field, the 10-year MDP will provide operating experience and confirm process design, economics, and environmental impacts.

Project Description

Access to the modular development area will be through a 4.6 m (15-foot) diameter service production shaft and a 3 m (10-foot) diameter ventilation shaft and the escape shaft all connected to the G level as shown in Figure A-3.

Shaft construction to a depth of approximately 295 m (970 ft) deep has been completed and outfitting is progressing. The process development retorts will be developed sequentially, so that the results from the previous retort could be incorporated into the development and processing of the next retort. Retort 0 would measure 9.1 m (30-feet) square by 61.0 m (200 ft) high and will provide Rio Blanco experience in rubblization and blasting techniques. There would be a minimum of instrumentation. Retort 1 will be nominally 18.3 m x 18.3 m by 122.0 m (60 ft by 60 ft by 400 ft) high and will be fully instrumented. It will be developed from the G level of the MDP mine upward to near the top of the Mahagony Zone. Retort 2 geometry will be decided from information obtained from rubblizing Retort 1. Two alternatives being considered include a pair of nominal 122.0 m (400 ft) high retorts burned either in sequence or together as a single retort of larger cross section. The remainder of the MDP will consist of burning additional retorts as high as technically feasible up to 213.5 m (700 ft) to optimize commercial design and operation plus developing a complement of commercial size retorts for operation to begin in 1987.

During the MDP, diesel-powered load-haul-dump (LHD) units and twin boom jumbos will create up to a 40 percent mined-out void. There will be no work under unsupported roofs of large spans. The new retort geometries within the G level eliminate the need for the C and E levels, and thus reduce raw shale storage by up to 50 percent. Once the raw shale has been lifted to the surface, it will be hauled by truck to the disposal areas where it will be contoured and revegetated.

Surface support facilities will be constructed during the MDP to provide combustion air and steam to the MIS retort. The product gas, oil and water will be separated underground and the individual streams pumped to the surface for treatment. The retort product gas, totaling about 1.84 million m^3/day (65 million SCFD) for the largest developmental retort will be incinerated and scrubbed in a sodium carbonate scrubber before being discharged to the atmosphere. The 102 tonne/day (750 bbl/day) of raw shale oil produced from the large retort will be hauled from the site by tank truck to a market point. Any water produced during retorting will be sent to a lined solar evaporation pond.

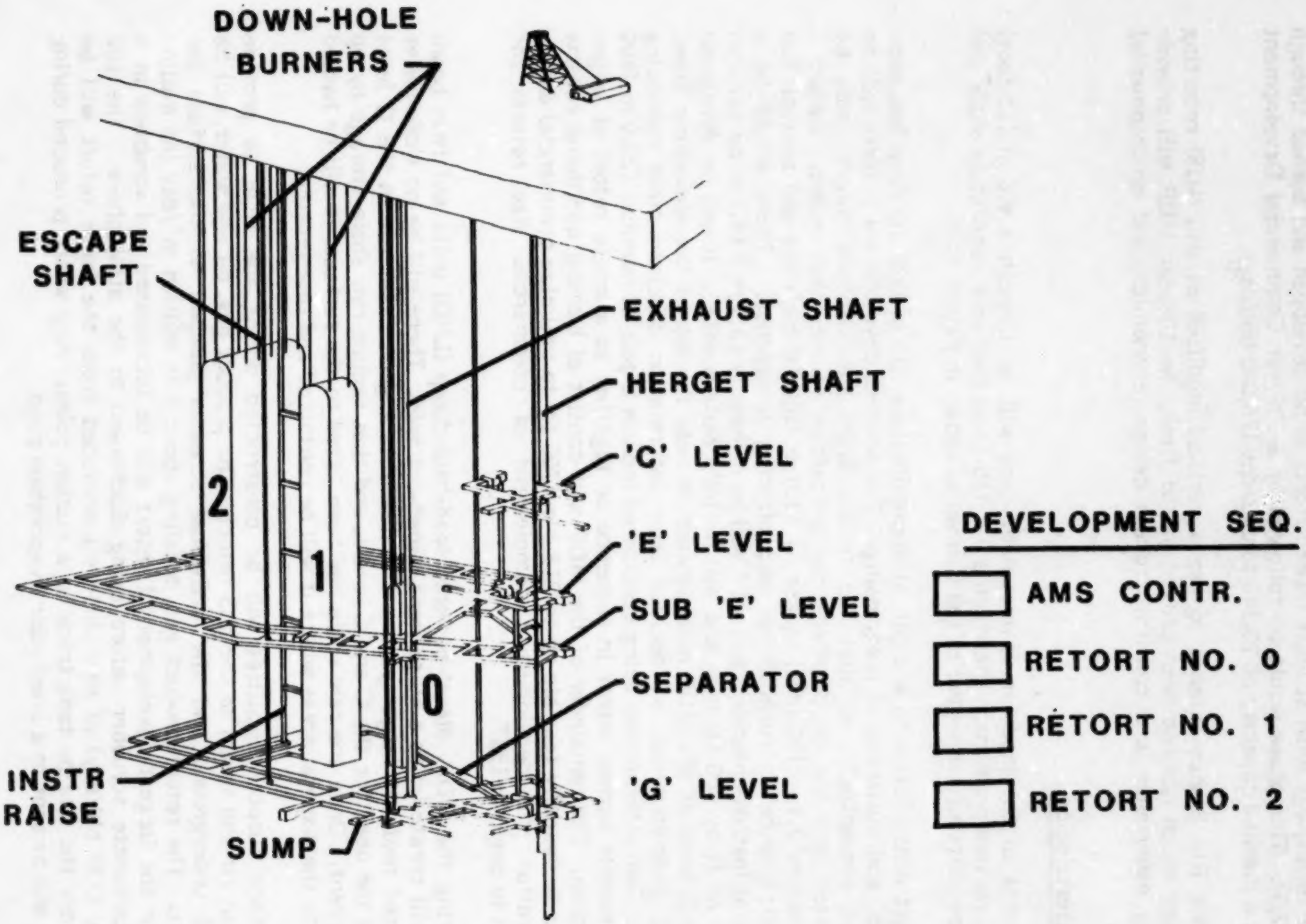

DOWN-HOLE BURNERS
ESCAPE SHAFT
EXHAUST SHAFT
HERGET SHAFT
'C' LEVEL
'E' LEVEL
SUB 'E' LEVEL
SEPARATOR
'G' LEVEL
INSTR RAISE
SUMP
2
1
0
DEVELOPMENT SEQ.
AMS CONTR.
RETORT NO. 0
RETORT NO. 1
RETORT NO. 2

Figure A - 3. Rio Blanco Oil Shale Co. MDP mine development.
(Source: Reference 3.)

Once operational and economic feasibility has been confirmed in the MDP, the final size and configuration for the commercial retorts will be determined and work will proceed. Access to the commercial mine would be made through a number of shafts, and a new processing facility would be constructed to clean up and burn low BTU gas and treat all water and waste streams before discharge. Data obtained during the MDP will be used for commercial plant design.

CATHEDRAL BLUFFS SHALE OIL CO.

In February 1974, Ashland Oil, Inc., Atlantic Richfield Co., The Oil Shale Corp. (TOSCO Corp.), and Shell Oil Co. submitted a high bid of $117.8 million for Tract C-b. In December 1975, Atlantic Richfield Co. and TOSCO withdrew from this joint venture, and on November 2, 1976, Shell Oil Co. announced its withdrawal from the C-b Oil Shale Project. On November 3, 1976, Ashland Oil, Inc., announced the formation of a new joint venture with Occidental Oil Shale, Inc. (Oxy) to proceed with the development of Tract C-b. In this new joint C-b Shale Oil Venture, Ashland granted Oxy a 50 percent interest (later increased to 75 percent) in the C-b lease and tract in exchange for the right to use the Oxy Modified In Situ (MIS) Process, which Oxy has developed and patented for the recovery of oil from shale. On February 14, 1979, Ashland withdrew from participation in the project. In September 1979, Tenneco joined Occidental as a 50 percent partner in the venture, now known as the Cathedral Bluffs Shale Oil Co.

The C-b lessees submitted a DDP to the Area Oil Shale Supervisor on February 9, 1976, outlining plans to develop the tract using room-and-pillar mining and surface retorts. Effective September 1, 1976 the lessees were granted a year's suspension of operation for the purpose of considering alternative methods of developing the tract. In February 1977, a modification to the DDP was submitted to the Area Supervisor which called for development of the tract by the use of the Oxy MIS process. The process consists of creating an underground chimney of broken oil shale by expanding the shale into a previously mined-out volume using conventional explosives. Tests have been conducted using both horizontal and vertical mined-out slots. The Oxy process is shown schematically in Figure A-4. A flame front is initiated at the top of the chimney and progresses downward, retorting the shale ahead of it. The shale oil product collects at the bottom of the retort and is pumped to the surface.

Project Description

Access to the mine will be through three shafts (production, service and gas), each of which will be 10.4 m (34 ft) in diameter. The production shaft will be used to remove mined shale as well as to serve as the main ventilation exhaust duct. The service shaft will serve as an intake for process and ventilation air, and it will also deliver men and materials to the mine production level. The gas shaft is for the removal of product gas.

About one year will be required for start-up. Initially two retorts will be started, then two clusters of four, and then full size clusters of eight retorts. During commercial production, approximately 40 retorts will be in various stages of processing at one time and will produce 7,752 tonnes/day (57,000 bbl/day) of shale oil. A flow diagram of the commercial operation for Tract C-b development is shown in Figure A-5. During retort operation, ventilation and process air flows will

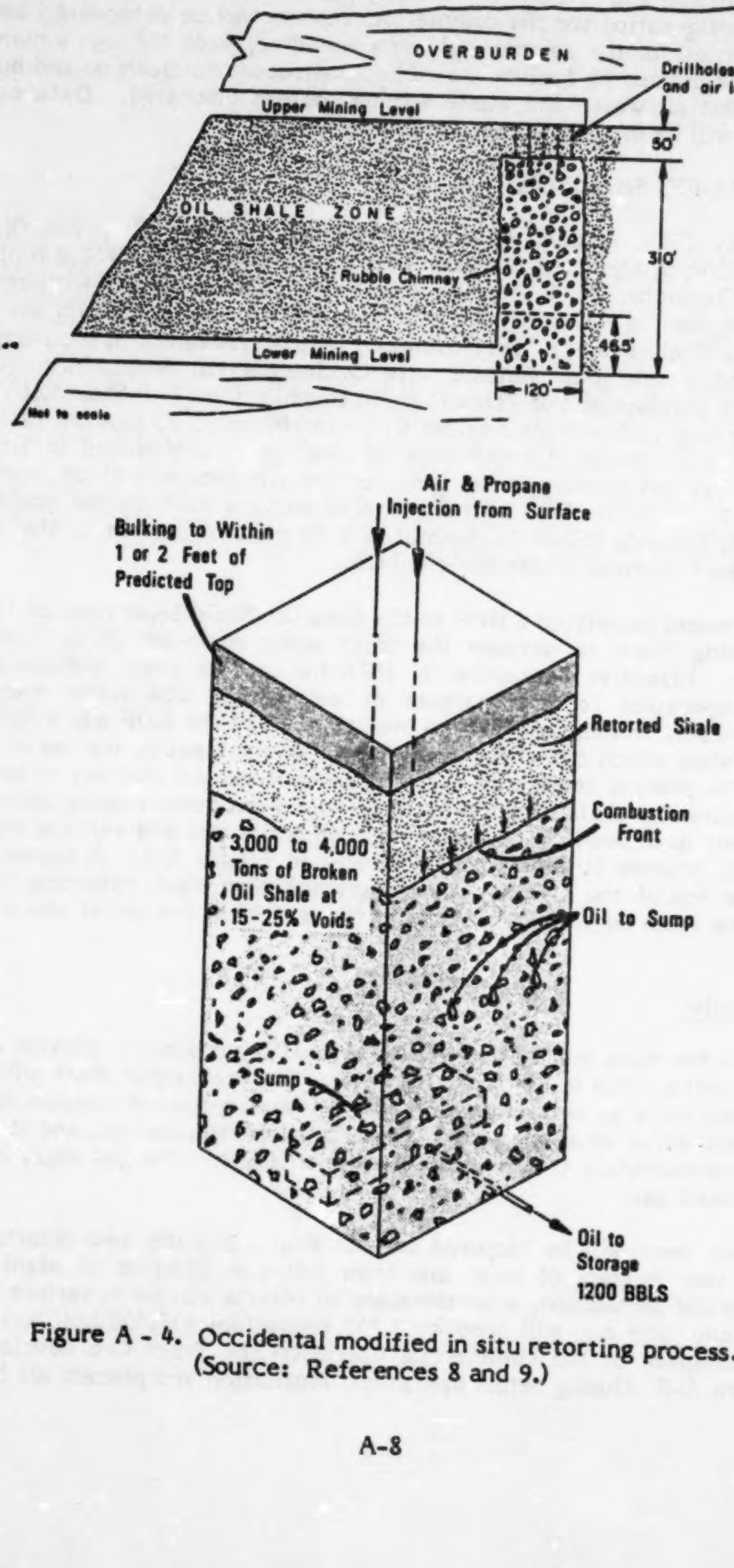
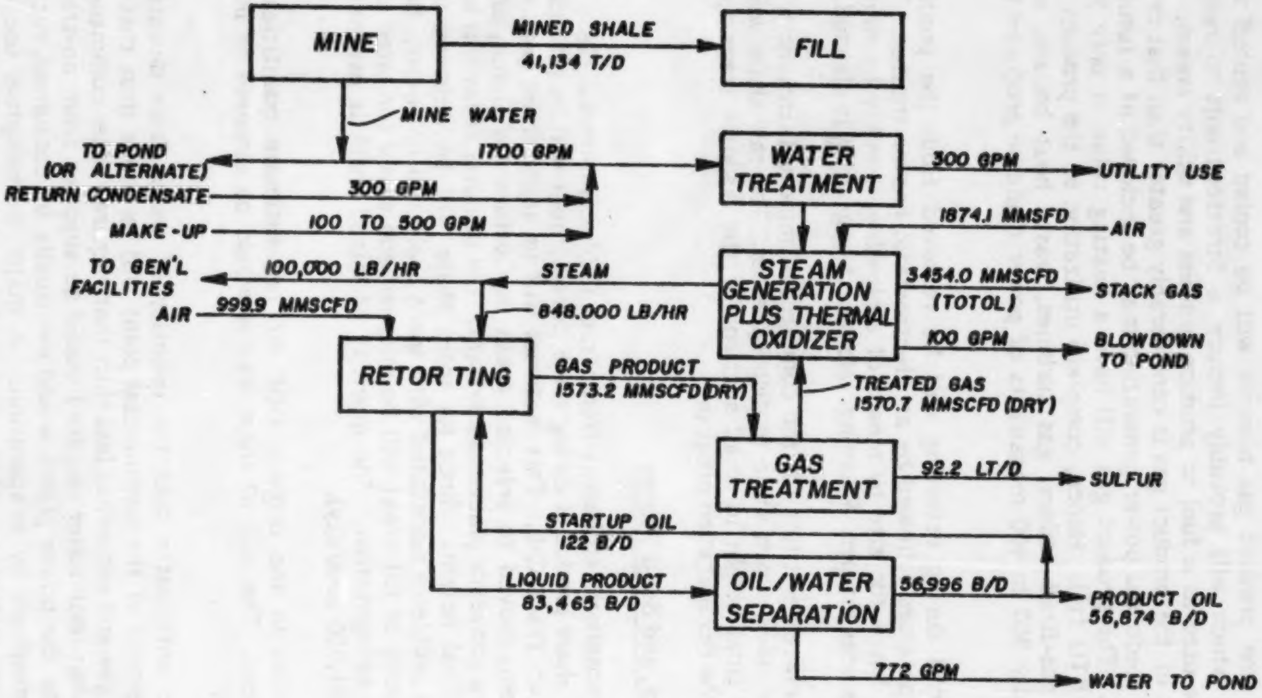

OVERBURDEN
Drillholes for explosives and air injection
Upper Mining Level
50'
OIL SHALE ZONE
310'
Rubble Chimney
46.5'
Lower Mining Level
120'
Not to scale
Air & Propane Injection from Surface
Bulking to Within 1 or 2 Feet of Predicted Top
Retorted Shale
Combustion Front
3,000 to 4,000 Tons of Broken Oil Shale at 15-25% Voids
Oil to Sump
Sump
Oil to Storage 1200 BBLS

Figure A - 4. Occidental modified in situ retorting process. (Source: References 8 and 9.)


MINE
MINED SHALE
41,134 T/D
FILL
MINE WATER
TO POND
(OR ALTERNATE)
1700 GPM
WATER TREATMENT
300 GPM
UTILITY USE
RETURN CONDENSATE
300 GPM
MAKE-UP
100 TO 500 GPM
1874.1 MMSFD
AIR
TO GEN'L FACILITIES
100,000 LB/HR
STEAM
STEAM GENERATION PLUS THERMAL OXIDIZER
3454.0 MMSCFD
(TOTOL)
STACK GAS
AIR
999.9 MMSCFD
848,000 LB/HR
100 GPM
BLOWDOWN TO POND
RETOR TING
GAS PRODUCT
1573.2 MMSCFD (DRY)
TREATED GAS
1570.7 MMSCFD (DRY)
GAS TREATMENT
92.2 LT/D
SULFUR
STARTUP OIL
122 B/D
LIQUID PRODUCT
83,465 B/D
OIL/WATER SEPARATION
56,996 B/D
PRODUCT OIL
56,874 B/D
772 GPM
WATER TO POND

From
THE RALPH M. PARSON COMPANY
PASADENA, CALIFORNIA

Figure A - 5. Flow diagram of proposed commercial operation on Tract C-b. (Source: Reference 7.)

be induced by blowers taking suction on the product gas shaft and the production shaft. Under these conditions, the retorts would be under negative pressure relative to the inhabited levels of the mine, thus preventing short circuiting of the product gas.

Vapors from the product gas blowers will be cooled and routed to the gas treating facilities which will probably include a Stretford unit to remove H_2S. Treated gas will be used as a fuel to produce process and utility steam. Since the total heat content of the product gas is considerably greater than that required for steam production, electrical power generation may be included at a future date to utilize excess gas. The product gas will have a heating value of only 534 to 623 kcal/m^3 (60 to 70 BTU ft^3). Hence, complete utilization of the product gas might include low-BTU, gas-fired boilers, gas turbines, waste heat boilers, and steam turbines. Potentially 300 to 400 megawatts of power could be produced for export from the site.

Water produced during retorting will be removed from the product oil in primary gravity separators followed by an electrostatic heater-treater. The crude shale oil will then leave the site by means of a pipeline, possibly by routing to an existing oil pipeline near Casper, Wyoming. No onsite upgrading is planned.

Additional surface facilities for the commercial mine will include a raw shale conveyor system to move mined shale to disposal sites. The raw shale will be built up in layers to its final height in small sections of the disposal areas to promote rapid initiation of the revegetation program.

Emissions, Effluents, and Solid Wastes

Estimated atmospheric emissions from Tract C-b's commercial plant are listed in Table A-1. Raw shale produced during mine development will be placed as fill in Cottonwood Gulch on Tract C-b. This material will be transferred onto a covered belt conveyor system, moved to selected areas in Cottonwood Gulch, and spread over these sites by a conveyor placement system. The disposal areas will be built up in layers to their final height. Since no spent shale will be disposed of on the surface, the special problems associated with spent shale will not exist. Before any fill is started, top soils in fill areas will be stripped and saved for later use as fill cover to facilitate revegetation. The quantity of mined shale is estimated to be 37,194 tonnes/day (41,000 tons/day).

The modification to the original DDP did not estimate quantities of solid wastes to be produced. The bulk of these wastes would be disposed of in the raw shale disposal areas.

The developer anticipates that the quantity of water from dewatering the mine during development of the commercial plant will be more than that required during the early stages and somewhat less than that required after commencing full-scale operation. Additional water required would be supplied from on-tract wells. All water supplied to the power plants would eventually be consumed, recycled, or released to the atmosphere by evaporation. A major consumptive use of water would be the moisturization of shale, for which all wastewater streams not otherwise recycled would be used. Water used for moisturizing shale for reclamation or dust control would either evaporate, be permanently incorporated

TABLE A-1. COMMERCIAL PLANT EMISSIONS FOR TRACT C-b[a]

Constituent	lb/hr	kg/hr
SO_2	174	79
NOx	588	267
Particulates	74	34
THC	15	7
CO	84	38

[a] Source: Reference 7.

into the waste pile, or drain into the catchment basin below the pile for recycle. Other consumptive uses would include steam generation for heating and process requirements, use as drinking water, evaporation losses, and use as irrigation water in revegetation (10).

WHITE RIVER SHALE PROJECT

The White River Shale Project was formed in June 1974 by the owners of the Federal oil shale lease to Tract U-a, the Phillips Petroleum Co. and Sun Oil Co., (now Sunoco Energy Development Co.) and the owners of the Federal oil shale lease to Tract U-b, Sohio Petroleum Co. (now the Sohio Natural Resources Co.). The purpose of the project was to prepare and implement a plan for the joint development of the two lease tracts. Phillips and Sun were awarded the U-a lease in May 1974 for a bonus bid of approximately $75.6 million. The White River Shale Oil Corp. (Phillips, Sun, and Sohio) was awarded the U-b lease for a bonus bid of approximately $45.1 million, but the tract has since been fully assigned to the Sohio Natural Resources Co.

The project has been suspended indefinitely by a court injunction suspending the lease terms based on property title questions. The leases are in jeopardy due to the existence of unpatented pre-1920 oil shale placer mining claims and by an application for a State lease to the same property by Penninsula Mining associated with Utah's in-lieu land selection procedure.

Project Description

The White River Project plans to follow a modular development approach in commercializing oil shale operations on Tracts U-a and U-b. The first major activity on the tracts would be to establish a room-and-pillar mine with its attendant access drifts. This Phase I developmental mine would better define the existing shale conditions on the tract that have an effect on future large-scale mining and processing operations. During this initial mining operation, about 27,215 tonnes (30,000 tons) of shale would be mined for crushing and retorting evaluations.

During Phase II, the exploratory mine would produce about 9,070 tonnes (10,000 tons) of oil shale per day, which would be crushed and fed to a single commercial sized vertical retort, probably of the Paraho design. Phase II development and operation would last for a period of about six years.

Successful initiation and operation of the single-surface retort would be followed by engineering and construction of a commercial plant during Phases III and IV. For the commercial plant producing 13,600 tonnes (100,000 bbl) of shale oil per day, the mining operations would produce about 145,150 tonnes/day (160,000 tons/day) of raw shale utilizing room-and-pillar techniques. The retort feed preparation would reduce the raw shale to the required size ranges in stages of crushing and screening, with primary crushing carried out in the mine. Coarsely crushed raw shale would be lifted to the surface and further reduced in size by secondary crushers. A stockpile of primary-crushed raw shale would be maintained to ensure steady operations.

Most raw shale from secondary crushing would be processed in vertical retorts, with direct-heated and indirect-heated retorts used to achieve the gas make and composition required by subsequent upgrading operations and process heat balance. The balance of the crushed raw shale would be processed in fines-processing retorts, probably of the TOSCO II design. A flow diagram of the commercial plant is shown in Figure A-6.

Spent shale disposal would be in Southam Canyon, a perennially dry drainage about .8 km (.5 mi) west of the plant site. The processed shale would be conveyed to the disposal area, where it would be placed and compacted by trucks. A small dam would be constructed below the disposal area to control runoff.

Current revegetation plans call for crushing and compacting the top 1 to 1.3 m (3 to 4 ft) of spent shale during disposal to control texture and reduce permeability. Soil additives and phosphorus fertilizer would also be added, and the surface shaped to create planting basins and water harvesting surfaces. Each planting basin would contain a trench filled with topsoil reclaimed from the disposal site. The water harvesting surface would be treated with sealants and stabilizers so that rain water would be shed into the planting basins (11,12).

Emissions, Effluents, and Solid Wastes

Estimated atmospheric emissions from White River Shale Project operations during the single retort operation, (Phase II) and the full-scale commercial plant (Phase IV) are listed in Table A-2. These estimates include emissions resulting from all mining, processing, waste disposal, and vehicular movement activities.

The estimated quantities of solid wastes requiring disposal during Phases II and IV are summarized in Table A-3. During Phase II, waste collected in slurry form would be used along with water to moisturize processed shale and would go to the disposal area on the processed shale conveyor and processed shale-hauling vehicles. Slurry waste would include raw and processed shale dust collected in wet scrubbers, water treatment filter sludges, and Stretford unit sulfur. Other solid wastes, such as trash and garbage from the mine and the plant area, would be accumulated in bins or other appropriate containers and picked up regularly by collection vehicles and transported to the disposal site. Digested biological sludge would be stored in drying

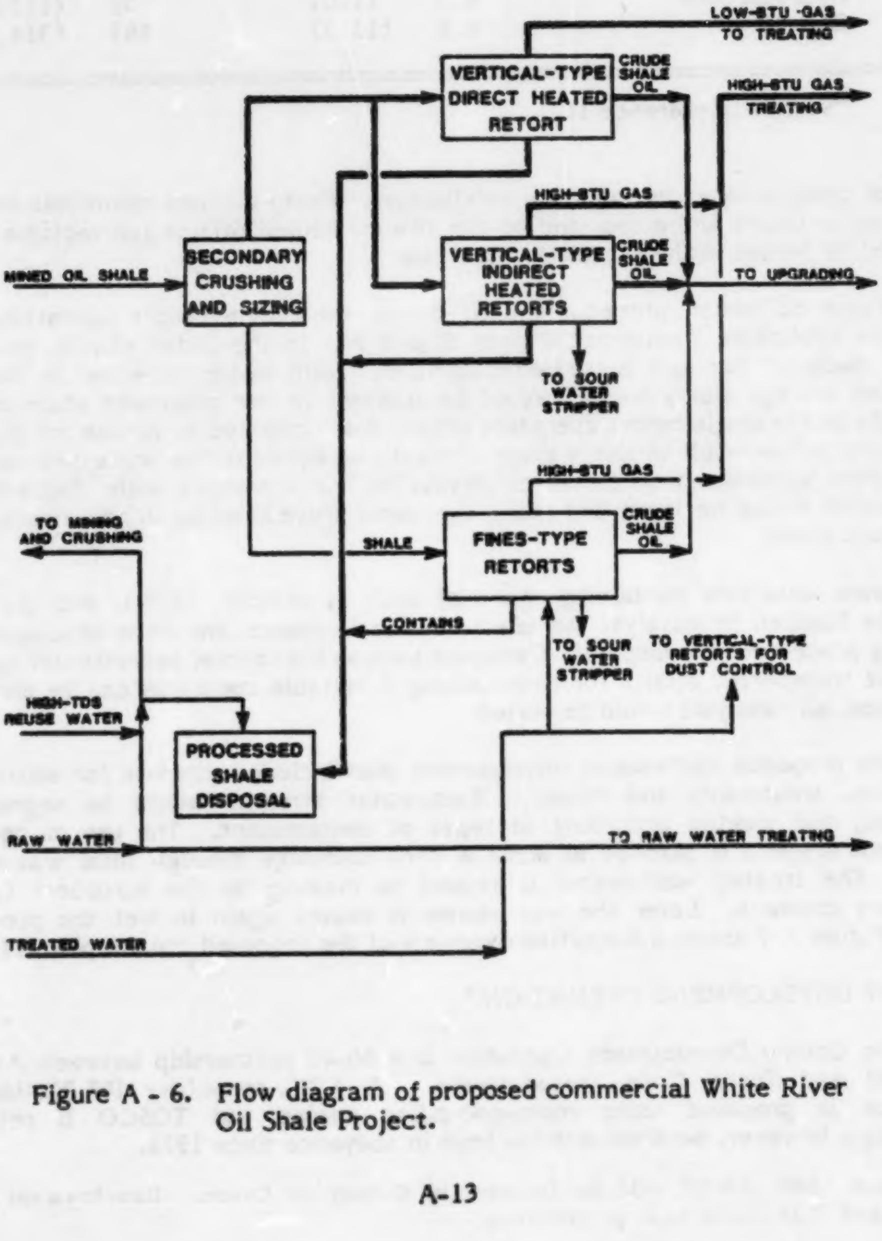

LOW-BTU GAS
TO TREATING
VERTICAL-TYPE
DIRECT HEATED
RETORT
CRUDE
SHALE
OIL
HIGH-BTU GAS
TREATING
HIGH-BTU GAS
VERTICAL-TYPE
INDIRECT
HEATED
RETORTS
CRUDE
SHALE
OIL
TO UPGRADING
MINED OIL SHALE
SECONDARY
CRUSHING
AND SIZING
TO SOUR
WATER
STRIPPER
HIGH-BTU GAS
TO MINING
AND CRUSHING
SHALE
FINES-TYPE
RETORTS
CRUDE
SHALE
OIL
CONTAINS
TO SOUR
WATER
STRIPPER
TO VERTICAL-TYPE
RETORTS FOR
DUST CONTROL
HIGH-TDS
REUSE WATER
PROCESSED
SHALE
DISPOSAL
RAW WATER
TO RAW WATER TREATING
TREATED WATER

Figure A - 6. Flow diagram of proposed commercial White River Oil Shale Project.

Table A-2. ESTIMATED ATMOSPHERIC EMISSIONS FOR THE WHITE RIVER SHALE PROJECT[a]

Emission	Phase II		Phase IV	
	kg/hr	(lb/hr)	kg/hr	(lb/hr)
SO_2	3.8	(8.4)	136	(300.4)
NOx	49.2	(108.4)	1227	(2,706.7)
Particulates	30.1	(68.0)	411	(906.6)
Hydrocarbons	0.5	(1.0)	52	(115.4)
CO	6.1	(13.5)	143	(314.4)

[a] Source: Reference 11.

beds for possible later use as a soil conditioner. Waste oils and chemicals would be collected in drums and either fed to the retort, hauled offsite for reclamation (if feasible), or buried in the processed shale pile.

Waste collection procedures used during the single retort operation phase would be applicable throughout Phases III and IV. In the latter phases, provisions will be made for handling increased quantities. Solid waste collected in the plant and mine (except slurry waste) would be trucked to the processed shale disposal area. As in the single retort operation phase, dust collected in various air pollution control facilities — all in slurry form — would be added to the processed shale and transported by covered or closed conveyors to the processed shale disposal area. Solid waste would be landfilled using the same procedures as in the single retort operations phase.

Spent catalysts containing material such as arsenic, nickel, and chromium would be handled by catalyst manufacturers or licensors who have developed safe handling procedures for disposal. Catalysts such as high nickel hydrotreater catalyst would be transported offsite for reprocessing if suitable contracts can be arranged. Otherwise, all catalysts would be buried.

The proposed wastewater management plan includes schemes for wastewater collection, treatment, and reuse. Wastewater streams would be segregated, collected, and treated according to types of contaminant. The use of optimum treatment systems is planned to achieve zero discharge through total wastewater reuse. The treated wastewater is reused as makeup to the scrubbers for the secondary crushers. Later the wastewater is reused again to wet the processed shale. Figure A-7 shows a simplified overview of the proposed control plan (11,12).

COLONY DEVELOPMENT OPERATION*

The Colony Development Operation is a 60-40 partnership between Atlantic Richfield and Tosco Corp., respectively. A 6,392-tonne/day (47,000-bbl/day) operation is proposed using room-and-pillar mining and TOSCO II retorting technology; however, development has been in abeyance since 1974.

*In August 1980, ARCO sold its interest in Colony to Exxon. Development by Exxon and TOSCO is now in progress.

Table A-3. ESTIMATED SOLID WASTES GENERATED BY THE WHITE RIVER SHALE PROJECT[a]

Waste	Phase II	Phase IV
Raw and processed shale dust from wet scrubbers	135.9 tonnes/day (149.8 tons/day)(wet)	10,054 tonnes/day (11,082.8 tons/day)
Elemental sulfur slurry (50% moisture)	4.2 tonnes/day (4.6 tons/day)	154.2 tonnes/day (170 tons/day)
General trash & garbage	0.36 tonnes/day (0.4 tons/day)	6.4 tonnes/day (7 tons/day)
Spent HDN Catalysts	---	1,187 tonnes/year (1,308 tons/year)
Hydrogen plant spent catalysts	---	371 tonnes/year (409 tons/year)
Deactivated carbon filter cake	---	40.8 tonnes/year (45 tons/yr)
Spent Claus unit catalyst	---	30.8 tonnes/year (34 tons/year)
Diatomaceous earth filter cake	---	51.7 tonnes/yr (57 tons/yr)
Water treatment sludge	---	274.4 tonnes/day (302.5 tons/day)
Skimmed Oils	---	27.2 tonnes/day (30 tons/day)

[a] Source: Reference 11.

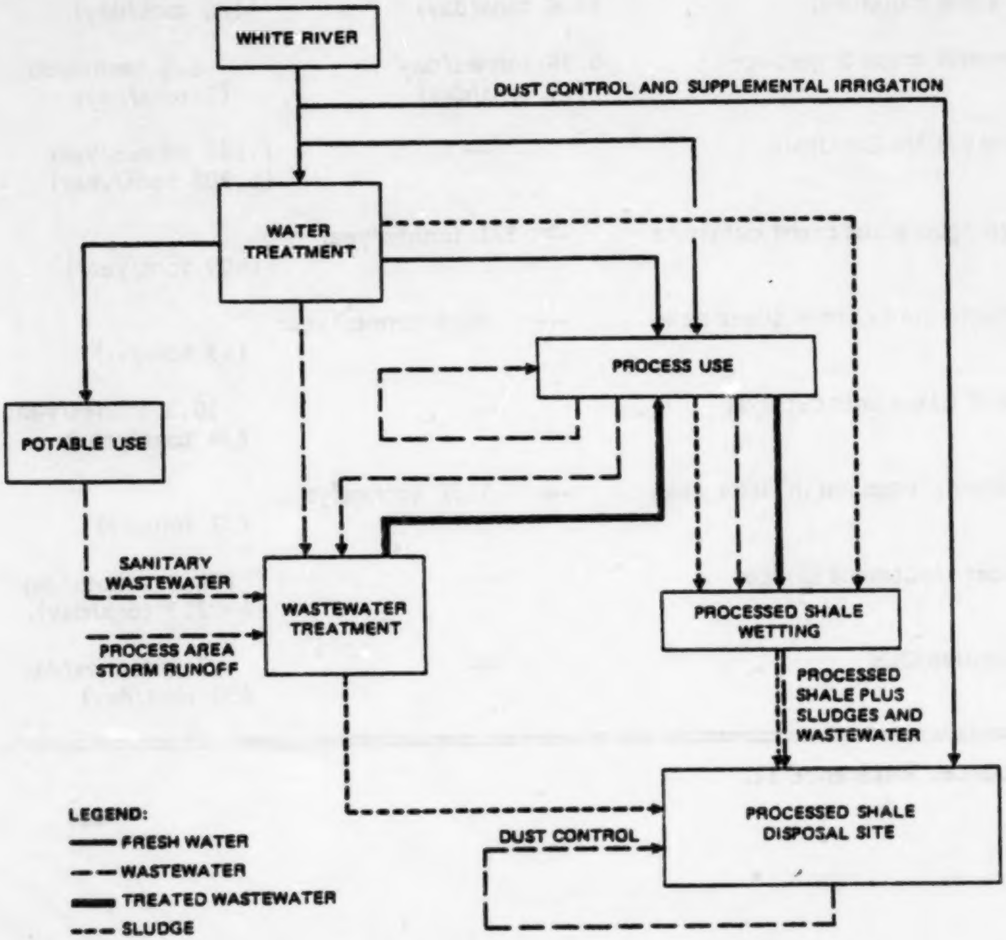

WHITE RIVER
DUST CONTROL AND SUPPLEMENTAL IRRIGATION
WATER TREATMENT
PROCESS USE
POTABLE USE
SANITARY WASTEWATER
PROCESS AREA STORM RUNOFF
WASTEWATER TREATMENT
PROCESSED SHALE WETTING
PROCESSED SHALE PLUS SLUDGES AND WASTEWATER
PROCESSED SHALE DISPOSAL SITE
DUST CONTROL
LEGEND:
FRESH WATER
WASTEWATER
TREATED WASTEWATER
SLUDGE

Figure A - 7. Proposed water control plan for White River Shale Project. (Source: Reference 11.)

Tosco joined with Sohio and Cleveland Cliffs Iron Comp. in 1964 to form the Oil Shale Venture. The official name of the group was later changed to Colony Development Co. As a result of the successful operation of the small pilot plant and favorable cost estimates, the group constructed a 900-tonne/day (1,000-ton/day) semi-works plant in 1965 on private property 17 miles north of Grand Valley, Colorado. Field operations were conducted for the next two years to demonstrate the operability of the semi-works plant, and in 1968, a design study was completed for a 59,870-tonne/day (66,000 ton/day) commercial-size complex.

Atlantic Richfield joined the Colony group in 1969, the same year a second semi-works program was initiated. This program was designed to study scale-up procedures and test environmental protection equipment required by the newly enacted Federal legislation. The semi-works plant was modified and tested from 1969 until April 1972.

Following evaluation of operating data from the semi-works plant and completion of a definitive engineering design and cost estimate for the commercial plant, in 1974, the Colony partners announced that the project was being shelved indefinitely because of economic uncertainty and the lack of a Federal energy policy.

Project Description

In the Colony Project, oil shale would be mined using conventional room-and-pillar methods at a design rate of 59,870 tonnes/day (66,000 tons/day). Run-of-mine ore would be hauled in trucks to a primary crusher located on the mine bench. The primary crusher would be rated at 4,082 tonnes/hr (4,500 tons/hr) and would operate intermittently. Run-of-mine ore would be reduced to a nominal minus 22.9 cm (9-in.) size. Coarse ore would be moved by belt conveyor through an inclined tunnel from the primary crusher to a fine crushing plant consisting of 10 individual crushing and screening operations designed to reduce the coarse ore to a minus 1.27 cm (0.5 in.) product. Fine ore would be transported by means of an enclosed conveyor to three storage silos, which in turn would feed six pyrolysis trains. Each of the six pyrolysis trains would essentially consist of a preheat system, a retorting section, and a processed shale cooling and moisturizing section. Each preheat section would be a dilute-phase fluidized bed arrangement that would utilize waste heat in retort flue gases.

A steam superheater would be required for each retorting section, as would an elutriator for the removal of residual spent shale dust from the ceramic balls. Combustion gases from the superheaters would be used in the elutriators. Each pyrolysis train would utilize a processed shale moisturizer to control dust and to obtain proper compaction properties.

Liquid products from the retorting section would be fractionated before upgrading. The upgrading section would include:

- A gas treating plant
- A sulfur recovery plant
- A hydrogen plant

- Hydrotreating facilities
- An ammonia separation plant
- A delayed coking plant
- Tankage and utilities

Retort gases would first be sent to a gas-treating plant for removal of hydrogen sulfide and carbon dioxide, and then consumed as fuel. Acid gas removal would be accomplished by conventional diethanolamine absorption, with acid gases sent to a Claus plant with a Wellman-Lord tail-gas cleanup unit.

Hydrogen generated by steam-methane reforming would be sent to separate hydrotreaters to product naphtha and gas oil fractions. The ammonia separation plant would recover ammonia from sour water produced in the hydrotreating reaction. Hydrogen sulfide from the ammonia separation plant and sour gases from the foul water stripper would be sent to the sulfur plant (13).

Emissions, Effluents, and Solid Wastes

Estimated emissions from the Colony plant during full-scale operation are presented in Table A-4. These estimates are based on observed emissions from Colony's semi-works plant and definitive engineering design by Colony (14,15).

Along with the processed shale, Colony proposes to dispose of various catalytic materials, carbon, small trees and brush cleared during construction operations, sludge from various processes, probably coke, and sludge from processed sanitary waste at the plant site. The specific method for disposing of spent catalyst and arsenic removal waste material in the processed shale embankment has not been firmly established. Colony's preferred alternative is to haul the material to the disposal area separately, spread the material over a large area of the shale, and mix it with the processed shale coming off the conveyor by spreading thin lifts of shale and then compacting with a sheeps's foot roller. Table A-5 shows the latest estimate of solid wastes to be generated by the plant and mine (15, 16).

Processed shale disposal would be carried out continuously at various locations in Davis Gulch-a high, shallow valley in the northwestern portion of Colony's Dow West Property. An embankment would be constructed of compacted, processed shale, behind which the remainder of the processed shale would be placed and compacted. A drainage system would be constructed to convey any surface water to a catchment dam to be constructed below the disposal pile.

Water used in the processed shale moisturizing process would constitute a major consumption of water. The processed shale pile would be the point of disposal for wastewater streams that are not recycled. Other consumptive uses of water would be the steam-reforming process to make hydrogen, drinking water, and the revegetation program. Water used for dust control in mining and crushing operations eventually would be released to the atmosphere by evaporation. Water used for moisturizing processed shale or for dust control on the processed shale embankment would either evaporate or become part of the processed shale embankment.

TABLE A-4. ESTIMATED EMISSIONS FROM THE COLONY SHALE OIL PLANT[a]

Source	Total average emissions, all stacks [b]kg/hr (lb/hr)									
	SO_2		NO_x		Hydrocarbons		Particulates		CO	
Preheat stacks	23.1	(51)	596.4	(1314.8)	122.5	(270)	36.7	(81)	19.9	(43.9)
Process shale wetters		----		----		----	17.4	(38.3)		----
Cold ball elutriators	42.8	(94.3)	51.4	(113.4)	0.1	(0.3)	17.1	(37.8)	1.3	(2.8)
Sulfur plant	42.9	(94.5)	0	(0)	0	(0)	0	(0)	0	(0)
Hydrogen furnaces	12.4	(27.4)	37.3	(82.2)	0.7	(1.6)	5.2	(11.4)	4.5	(9.9)
Naphtha heaters	0.2	(0.4)	0.6	(1.3)	0.05	(0.1)	0.1	(0.2)	0.1	(0.2)
Gas oil heaters	0.4	(0.9)	0.3	(0.7)	0.05	(0.1)	0.2	(0.4)	0.2	(0.4)
Gas oil reboiler	1.7	(3.8)	5.1	(11.2)	0.1	(0.2)	0.7	(1.6)	0.6	(1.4)
Coker feed heater	1.3	(2.8)	3.8	(8.4)	0.1	(0.2)	0.5	(1.1)	0.5	(1.0)
Boiler	3.3	(7.2)	9.8	(21.6)	0.2	(0.4)	1.3	(2.9)	1.2	(2.6)
Secondary crusher		----		----		----	14.9	(32.9)		----
Fine ore storage		----		----		----	1.9	(4.2)		----
Utility boilers	0.2	(0.4)	0.4	(0.8)	0	(0)	0.05	(0.1)	0.05	(0.1)
Primary crusher		----		----		----	3.3	(7.2)		----
Portal transfer		----		----		----	0.2	(0.4)		----
Transfer tower		----		----		----	2.3	(5.0)		----
Reclaim tunnel		----		----		----	2.5	(5.6)		----
Total:	128.3	(282.8)	706.0	(1556.4)	123.8	(272.9)	104.4	(230.2)	28.3	(62.3)

[a] Source: Reference 14.

[b] Total tonnes/year (tons/year) are as follows: SO_2, 1, 1,124 (1,239); NO_x, 6,184 (6,817); HC, 1,084 (1,195); particulates, 914 (1,008); CO, 248 (273).

TABLE A-5. ESTIMATED SOLID WASTES GENERATED BY THE COLONY PROJECT[a]

Waste	Amount generated			
Processed shale	48,262	tonnes/day	(53,200	tons/day)
Raw and processed shale dust	1,264	tonnes/day	(1,393	tons/day)
Spent catalysts from upgrading, hydrogen, and sulfur units	723-923	tonnes/year	(797-1017	tons/year)
Spent aqueous caustic from hydrogen unit	2.2	tonnes/day	(2.4	tons/day)
Diatomaceous earth from gas treating unit	195	tonnes/year	(215	tons/year)
Deactivated carbon from gas treating unit	195	tonnes/year	(215	tons/year)
Green coke from coke unit	726	tonnes/day	(800	tons/day)
Lime and alum flocculants from water treatment	199	tonnes/year	(219	tons/year)
Coagulant aid from water treatment	8.2	tonnes/year	(9	tons/year)

Source: References 13 and 16.

Water recovered from the various process units and water treatment facilities within the plant complex would either be recycled within the retorting and upgrading units or utilized to moisten processed shale.

The cooling water system would be composed of a complex network of piping over the entire processing area. About 136,270 l/min (36,000 gpm) of cooling water would circulate throughout the plant and would eventually return to a multiple-cell cooling tower. The cooling tower would incorporate an induced-draft system and would produce a visible water vapor plume. Cooling water blowdown would be used to moisturize processed shale (15,16,17).

UNION OIL COMPANY

The Union Oil Co. of California has been involved in oil shale activities for half a century, beginning in the 1920's with the purchase of 12,150 ha (30,000 acres) of fee property in the Piceance Creek Basin, 8,100 ha (20,000 acres) of which are oil-shale-bearing. The development of Union's oil shale retorting technology was initiated in the early 1940's, and three variations of an upflow vertical kiln process have been developed:

- Retort A
- Steam Gas Recirculation (SGR)
- Retort B

The Retort A process was tested in 1.8 and 45-tonne/day (2 and 50 ton/day) plants, followed by construction and operation of a large demonstration plant in Colorado in the late 1950's. This demonstration plant was designed for a 318 tonne/day (350 ton/day) capacity, but long-term operability was demonstrated at rates of 635 to 900 tonnes/day (700 to 1,000 tons/day), with a peak rate of 1,088 tonnes/day (1,200 tons/day). Although demonstration of the Retort A process was extensive and successful, most work was suspended because of a plentiful supply of low-cost natural gas and imported petroleum.

Two improved versions of the upflow retorting process, the Retort B and SGR, were developed in the 1970's in response to increasing energy demands and shortage of fuel supplies. Both the Retort B and SGR have been carried through pilot plant stages.

Given the proper economic and political climate, it is the Retort B process that Union proposed to construct and demonstrate at a 9,000 tonne/day (10,000 ton/day) rate. The SGR technology may be retrofitted at a later stage of development. This project is called the Long Ridge Experimental Shale Oil Project.

Project Description

The processing area for the demonstration plant is proposed for a five-acre bench on the north side of the east fork of Parachute Creek. Conventional room-and-pillar mining will be employed. Primary and secondary crushing will be done underground. The Retort B process would be used to extract the shale oil from the rock. Production would be 1,224 tonnes/day (9,000 bbl/day) from selectively mined 171 liter/tonne (41 gal/ton) shale.

Approximately 7,602 tonnes/day (8,380 tons/day) of retorted shale from the retort at the mine mouth will be transported by conveyor and disposal chute to a truck-loading hopper, loaded into 91-tonne (100-ton) bottom dump trucks, and laid down in windrows along the canyon wall. The retorted shale will be compacted to form a stable landfill.

Union Oil has estimated that 32 months will be required to design and construct the experimental plant with all its auxilliary facilities. The operating program will include an assessment of the technical, economical, and environmental feasibility of the Retort B process.

Emissions, Effluents, and Solid Wastes

Retort makegas would be first sent to a Venturi scrubber for cooling and oil mist removal. That portion of the 7,120 kcal/m^3 (800 BTU/scf) gas not recycled would be processed by compression and oil scrubbing to remove additional naphtha and heavy ends, followed by hydrogen sulfide removal in a Stretford unit. The sweetened makegas would be used as a plant fuel.

Product oil withdrawn from the retort would be treated sequentially for solids and light ends naphtha removal. Solids removal would be accomplished by two stages of water washing. Shale fines collected in the water phase would be recycled to the water seal. The water seal is a Union Oil concept in which a water level is maintained in a conveyor system for retorted shale removal to seal the retort pressure from atmosphere. For arsenic removal, a proprietary Union Oil process employing an absorbent would be used to reduce the arsenic content of the raw shale from 50 to 2 ppm. The shale oil would then be sent to a stripping column for stabilization before shipment. The resulting crude shale oil would be characterized as follows:

API gravity	22.7°
Pour point	16°C (60°F)
Nitrogen	1.7%
Sulfur	8.8%
Conradson carbon residue	1.75%

For the Retort B process, all the plant fuel requirements would be met by the makegas produced. The principal pollution control devices in the Union Oil design include the Stretford process for hydrogen sulfide removal from the retort makegas and oil/water separation and sour water stripping for wastewater treatment. The treated wastewater would be returned to the water seal for cooling and moistening retorted shale to provide for dust control and proper compaction.

Union has conducted studies on the various environmental impacts to be encountered in the Long Ridge Experimental Shale Oil Project. Among the control technologies to be employed are the following:

- A dust suppression system will be used for dust from both mining and crushing operations.
- Because of the oil seals on the feed inlet and water seals on the retorted shale discharge, the retort will be essentially free of particulate emissions. The plant will not discharge any wastewaters. All runoff that has contacted retorted shale will be impounded and reused.
- Quenched and cooled retorted shale (29 percent moisture) will be transported to the disposal site and compacted to a dry density of 1.5 g/cm^3 (93 lb/ft^3). A collection ditch will gather disposal pile runoff and discharge this water to collection ponds. Water impounded in the collection ponds will be pumped to the retorting plant for use as process water. The outer slopes and top of the retorted shale disposal piles will be revegetated.

A summary of estimated emissions from Union's proposed Long Ridge Experimental Shale Oil Project is given in Table A-6.

THE SUPERIOR OIL CO.

Superior Oil has owned some 2,632 ha (6,500 acres) of oil shale land in the northern Piceance Creek Basin for nearly 40 years. In 1967, it began a drilling and geological evaluation program and found that the deeper shales on the property contained attractive quantities of nahcolite (NaHCO^3) and dawsonite (NaAl(OH)$_2$CO$_3$), as well as oil shale. A research program was therefore initiated to

TABLE A-6. ESTIMATED EMISSIONS FROM UNION'S PROPOSED LONG RIDGE EXPERIMENTAL SHALE OIL PROJECT[a]

Source	Estimated (design) emissions kg/hr (lb/hr)									
	SO_2		TSP		NO_x		CO		HC	
Mining										
Blasting		0	10.2	(22.5)	6.1	(13.5)	3.8	(8.3)	0	0
Drilling, loading, hauling	0	0	0.5	(1.1)	0	0	0	0	0	0
Crushing	0	0	2.0	(4.3)	0	0	0	0	0	0
Shale preparation	0	0	2.3	(5.1)	0	0	0	0	0	0
Adit screening	0	0	3.2	(7.1)	0	0	0	0	0	0
Retorting & product handling										
Retort feed	0.06	(0.13)	0.2	(0.5)	0	0	0	0	0	0
Recycle gas heater	27.4	(60.3)	0.3	(0.6)	29.5	(65)	14.5	(32)	0.5	(1.0)
Steam boiler	8.7	(19.2)	0.1	(0.3)	8.6	(19)	7.7	(17)	0.1	(0.3)
Fractionator reboiler	0.6	(1.35)	0.01	(0.02)	0.7	(1.5)	0.6	(1.4)	0.01	(0.03)
Process equipment	0	0	0	0	0	0	0	0	9.1	(20)
Retort vent stack	0.06	(0.13)	nil	nil	0.03	(0.06)	0.03	(0.06)	nil	nil
Product storage	0	0	0	0		0	0	0	1.7	(3.8)
Vapor disposal	0	0	nil	nil	0.2	(0.4)	0.1	(0.2)	nil	nil
Retorted shale disposal										
Transfer	0	0	0	0	0	0	0	0	3.2	(7.1)
Wind erosion	0	0	0.5	(1.0)	0	0	0	0	4.9	(10.8)
Total	36.8	(81.1)	19.3	(42.5)	45.1	(99.5)	26.8	(59.0)	19.5	(43.0)

Source: Reference 18.

[b] Total tonnes/year (tons/year are as follows: SO_2, 322 (355); TSP, 169 (186); NO_x, 396 (436); CO, 234 (258); HC, 171 (188).

permit integrated recovery of these minerals and shale oil. Also included were investigations into the development of a circular grate retort.

Superior's property is shaped like a long narrow "L". Since underground mining is planned for the commercial project, their property is not amenable to optimum layout of ventilation, haulage, and access systems. Thus, Superior applied to the Bureau of Land Management (BLM) in 1973 for an exchange of 1,041 ha (2,572 acres) of their land for some 828 ha (2,045 acres) of adjacent Federal land to block up a more manageable tract for commercial development. A draft EIS has been prepared by BLM on the exchange application.

Project Description

Superior's commercial multi-mineral project, as shown in Figure A-8, would involve underground room-and-pillar mining to a depth of 610 m (2,000 ft), and surface processing for the production of nahcolite, oil, alumina, and sodium compounds. Average daily production of these products during full-scale operations would amount to:

nahcolite	-	4,425 tonnes (4,878 tons)
alumina	-	526 tonnes (580 tons)
soda ash	-	912 tonnes (1,005 tons)
shale oil	-	1,576 tonnes (11,586 barrels)

An average of 23,600 tonnes (26,200 tons) of oil shale per calendar day would be mined, crushed underground, and transported by conveyor to the nahcolite recovery unit. Nahcolite would then be separated from mine run material by a selective crushing and photosorting technique (19).

Oil shale exiting the nahcolite recovery unit would then be fed in three streams to a traveling circular grate retort. A commercial-sized module is expected to be about 61 m (200 ft) in diameter, with a capacity of 19,960 tonnes (22,000 tons) per day. Cooled shale from the retort would be fed to the leaching plant for recovery of alumina and soda ash. Processed shale would then be returned to the underground mine for disposal. Revegetation of spent shale would, therefore, not be required. Most water requirements for the full-scale plant are to be satisfied by utilizing saline water from the "leached zone" aquifer directly above the proposed mine. This water would first be used in the alumina and soda ash leach plant. Condensate ultimately recovered from the leaching plant would be used for major plant water needs. Potable and supplies would be obtained from condensed water from the soda ash and alumina processing units.

Emissions, Effluents, and Solid Wastes

Estimated air emission for Superior's commercial multi-mineral project are presented in Table A-7. These are average values expected. Processed shale, sludge, and collected dust would be backfilled in the mine to avoid surface disposal and help retard degradation of mine pillars. Approximately 12,660 tonnes (13,950 tons) per day of processed shale, along with 2.3 tonnes (2.5 tons) of sludge from the sewage treatment facilities, 1 tonne (1.1 ton) of lime sludge from the process water treatment plant, 115 tonnes (127 tons) of dust from the baghouses and, 1,000 tonnes (1,100 tons) of dust from crushing and screening operations would be returned to the

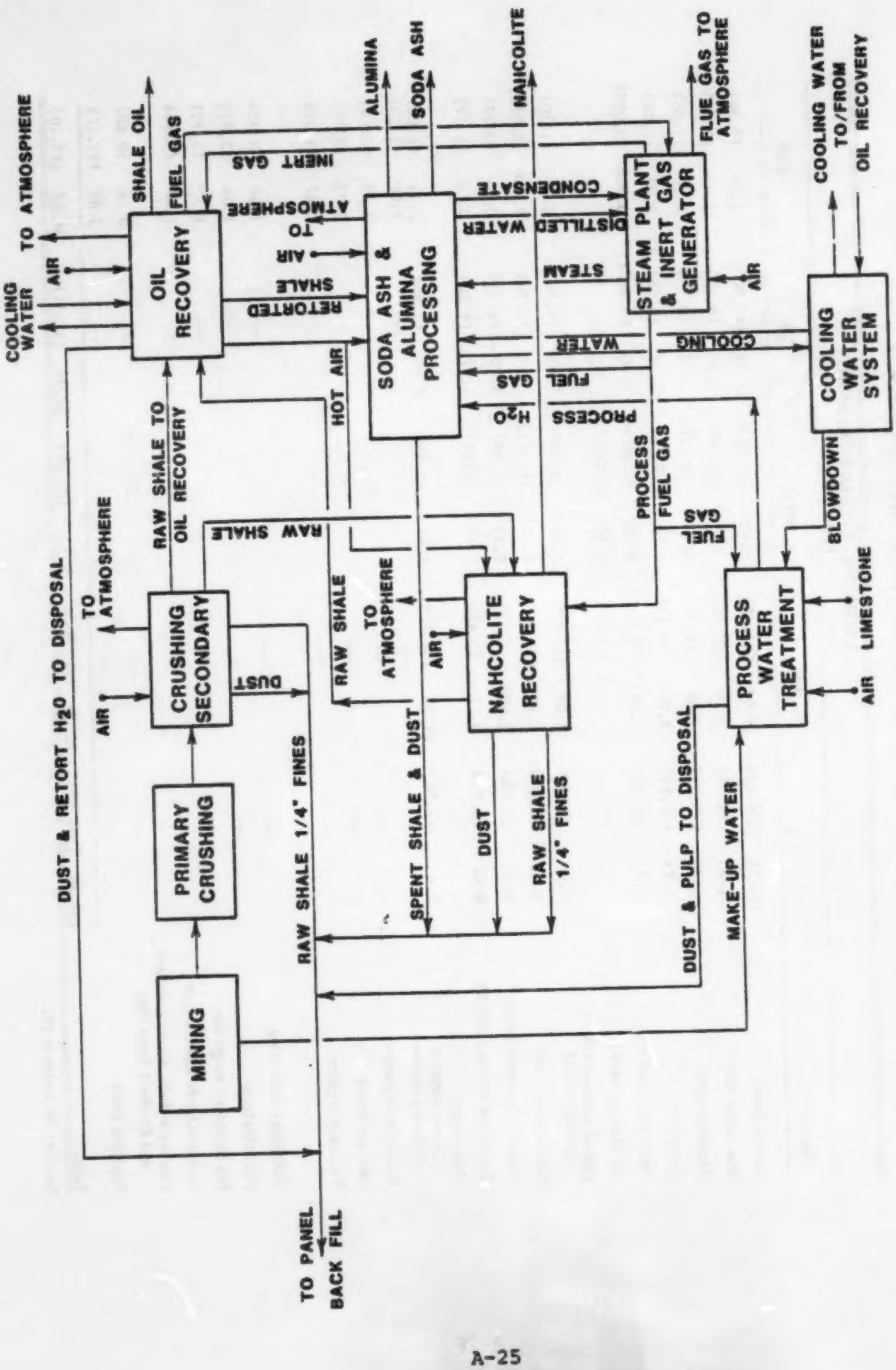

MINING
PRIMARY CRUSHING
CRUSHING SECONDARY
OIL RECOVERY
SODA ASH & ALUMINA PROCESSING
NAHCOLITE RECOVERY
STEAM PLANT & INERT GAS GENERATOR
PROCESS WATER TREATMENT
COOLING WATER SYSTEM
COOLING WATER
AIR
TO ATMOSPHERE
SHALE OIL
FUEL GAS
INERT GAS
RETORTED SHALE
AIR
TO ATMOSPHERE
ALUMINA
SODA ASH
NAHCOLITE
CONDENSATE
DISTILLED WATER
STEAM
FLUE GAS TO ATMOSPHERE
AIR
COOLING WATER
FUEL GAS
PROCESS H2O
HOT AIR
COOLING WATER TO/FROM OIL RECOVERY
RAW SHALE TO OIL RECOVERY
RAW SHALE
RAW SHALE
TO ATMOSPHERE
AIR
TO ATMOSPHERE
AIR
DUST
PROCESS FUEL GAS
FUEL GAS
BLOWDOWN
LIMESTONE
AIR
DUST & RETORT H2O TO DISPOSAL
RAW SHALE 1/4" FINES
SPENT SHALE & DUST
DUST
RAW SHALE 1/4" FINES
DUST & PULP TO DISPOSAL
MAKE-UP WATER
TO PANEL BACK FILL

Figure A - 8. Flow diagram of proposed Superior Oil project.

TABLE A-7. ESTIMATED EMISSIONS FROM SUPERIOR'S PROJECT

Source	ESTIMATED AVERAGE EMISSIONS kg/hr (lb/hr)				
	SO_2	NO_x	NMHC	CO	TSP
Steam plant	139.80 (308.20)	19.05 (42.00)	0.45 (1.00)	7.71 (17.00)	2.27 (5.00)
Nahcolite kiln	1.89 (4.16)	5.44 (12.00)	0.02 (0.04)	0.10 (0.23)	1.43 (3.15)
Alumina kiln	6.90 (15.22)	3.87 (8.54)	0.07 (0.15)	0.38 (0.83)	6.80 (15.00)
Lime kiln	4.73 (10.43)	1.06 (2.33)	0.05 (0.10	0.27 (0.60)	2.27 (5.00)
Inert gas generator	0.17 (0.37)	.004 (0.008)	0.001 (0.003)	0.008 (0.017)	0.002 (0.005)
Oil storage tanks	—	—	6.80 (15.00)	—	—
Diesel exhaust (shale storage area)	0.68 (1.50)	8.07 (17.80)	0.64 (1.40)	1.95 (4.30)	0.59 (1.30)
Gasoline exhaust	0.007 (0.015)	0.124 (0.273)	0.168 (0.371)	5.13 (11.30)	0.008 (0.017)
Product transportation	0.32 (0.70)	0.60 (1.33)	0.32 (0.71)	3.05 (6.73)	0.15 (0.32)
Employee transportation	0.02 (0.05)	0.21 (0.47)	0.20 (0.45)	1.91 (4.20)	0.05 (0.11)
Mine Vent					
Diesel exhaust	2.86 (6.30)	39.55 (87.20)	0.61 (1.34)	0.86 (1.90)	2.72 (6.00)
Primary crusher	—	—	—	—	1.00 (2.20)
Secondary crusher	—	—	—	—	2.99 (6.60)
Storage dome	—	—	—	—	0.95 (2.10)
Tertiary crusher	—	—	—	—	0.67 (1.47)
Nahcolite screening	—	—	—	—	1.06 (2.33)
Photosorters	—	—	—	—	1.06 (2.33)
Oil recovery surge bin	—	—	—	—	1.95 (4.30)
Alumina/soda ash crusher	—	—	—	—	2.68 (5.90)
Conveyor belt, Misc. Handling, and Product Load Out	—	—	—	—	0.36 (0.80)
Fugitive Dust	—	—	—	—	5.07 (11.17)
Total	157.38 (346.95)	78.00 (171.95)	9.33 (20.56)	21.37 (47.11)	34.07 (75.10)

Source: Reference 19.

mine. Before being conveyed to the mine, the mixture would be wetted with about 697,500 liters (180,000 gallons) of water daily from the oil and water separation tank associated with the oil recovery unit. Another 13.95 million liters (3.6 million gallons) per day of mine water would be added to the mixture to bring the moisture content of the resulting slurry to 50 percent. The slurry would then be pumped to the mine panels for backfilling.

Drain pipes laid along the panel floors would collect the percolating water drained from the slurry, which would then be pumped back to the slurry plant for reuse. As a result of the natural down dip of the panels, each would be filled to the roof and then sealed with concrete. Utilizing this disposal scheme all solid and liquid wastes from the plant will be returned in slurry form to the mine.

TOSCO SAND WASH PROJECT

The TOSCO Corp. has leases on five tracts of land totalling 5,949 ha (14,688 acres) at its Sand Wash Oil Shale property about 56 km (35 miles) south of Vernal, Utah. The company is in the second year of an eight year plan, under terms of a unitization agreement with the State of Utah to prepare the leases for eventual commercial development. In December 1978, the Utah Conservation Committee and the State Division of Oil, Gas, and Mining issued permits for the TOSCO Corp. to sink an experimental mine shaft on the Sand Wash properties.

The experimental mine shaft will have a diameter of 3.67 m (12 ft) and a depth of 732 m (2,400 ft). Initial field work is scheduled to begin in 1979, with the shaft estimated to be completed in 18 months to 3 years. An experimental mining program will follow when the shaft sinking is completed. During this experimental mining phase no onsite processing of the oil shale is planned, but shale samples will be sent to TOSCO's Research Center near Golden, Colorado for retorting in a 104.3-l/tonne (25-ton/day) TOSCO II pilot plant. Information from the experimental mining program will be used to help prepare final design criteria for a commercial facility.

TOSCO recently completed a preliminary design and updated cost estimate for eventually building a commercial-sized plant at Sand Wash. The proposed commercial plant would use the company's aboveground TOSCO II Process to extract petroleum liquids, gases and byproducts from crushed oil shale rock. Six 9,980-tonne/day (11,000-ton/day) TOSCO II retort modules would be included, along with equipment for product storage and loading, utilities, and disposal of spent shale.

Currently, a series of environmental studies are being conducted at the site through TOSCO's Vernal office, including revegetation of spent shale, meteorology, air quality, water resources, and surveys of flora and fauna. These studies are directed toward the future preparation of an EIS for the commercial project.

OCCIDENTAL OIL SHALE, INC.

On September 30, 1977, Occidental Oil Shale, Inc. and the Energy Research and Development Administration (now DOE) signed a cost-sharing contract, the total estimate cost of which is $60.6 million. The government will provide 71 percent and Occidental, 29 percent for Phase I. The contract was effective retroactive to November 1, 1976.

The overall objective of this project includes engineering development (Phase I), and technical feasibility demonstration (Phase II) of a vertical modified in situ oil shale retorting process based on Occidental's design and prior R&D work. Another objective is the determination of environmental effects from the recovery process.

Phase I evaluated two specific retort designs involving alternate means of mining and rubblizing at a size configuration approximately equivalent to commercial-sized retorts. The purpose of this evaluation is to select a particular retort design to be utilized in the Phase II technical feasibility demonstration. Both phases are being conducted at the D. A. Shale site near De Beque, Colorado. A schematic of the site is shown in Figure A-9.

During Phase I, Occidental rubblized and processed Retort 5 (vertical slot, with retort approximately 36.5 by 36.5 by 61 m or 120 by 120 by 200 ft) and Retort 6 (horizontal slot, with retort approximately 48.8 by 48.8 by 54.9 m or 160 by 160 by 180 ft) to determine the effect of retort configuration on gas flow patterns (as they indicate void volume and particle size distribution), and pressure differentials. Also studied will be the effect on oil yield of air/steam mixtures as the retorting medium, off-gas composition and heating value, process water requirements, energy requirements, and acceptable methods of retort ignition.

A comparison will be made between the two retort configurations to evaluate the technical and economic differences in mining, blasting, and processing as well as the differences in oil yield, off-gas composition and heating value, and process water requirements.

Occidental will conduct an environmental research program to collect data and evaluate the following:

- Hydrology and water resources of the area
- Meteorology, air quality, and gaseous emissions in the area
- Biological and health effects
- Societal influences
- Generation of research data required to obtain operating permits.

In November 1979, EPA issued the conditional PSD permit to operate Retorts 7 and 8. The approximate dimensions of these retorts are 47.2 m by 64.1 m by 78.9 m (165 by 165 by 268 ft). Table A-8 details the air emissions allowed by the permit. Oxy is required to enter into written agreement with EPA and DOE for the performance of an air emissions research testing program on Retorts 7 and 8. At a minimum, Oxy will provide a Stretford unit which will be operational on a slipstream of the retort off-gas. Oxy is negotiating with the EPA, Colorado APCD, and DOE to modify this test program to consist of a pilot combustor and pilot FGP system. Oxy will also provide the opportunity to EPA and DOE for sampling and characterization of this slipstream (21).

During Phase I, a market study for shale oil and a definitive design and cost estimate for a 680-tonne/day (5,000-bbl/day) demonstration plant and a firm design

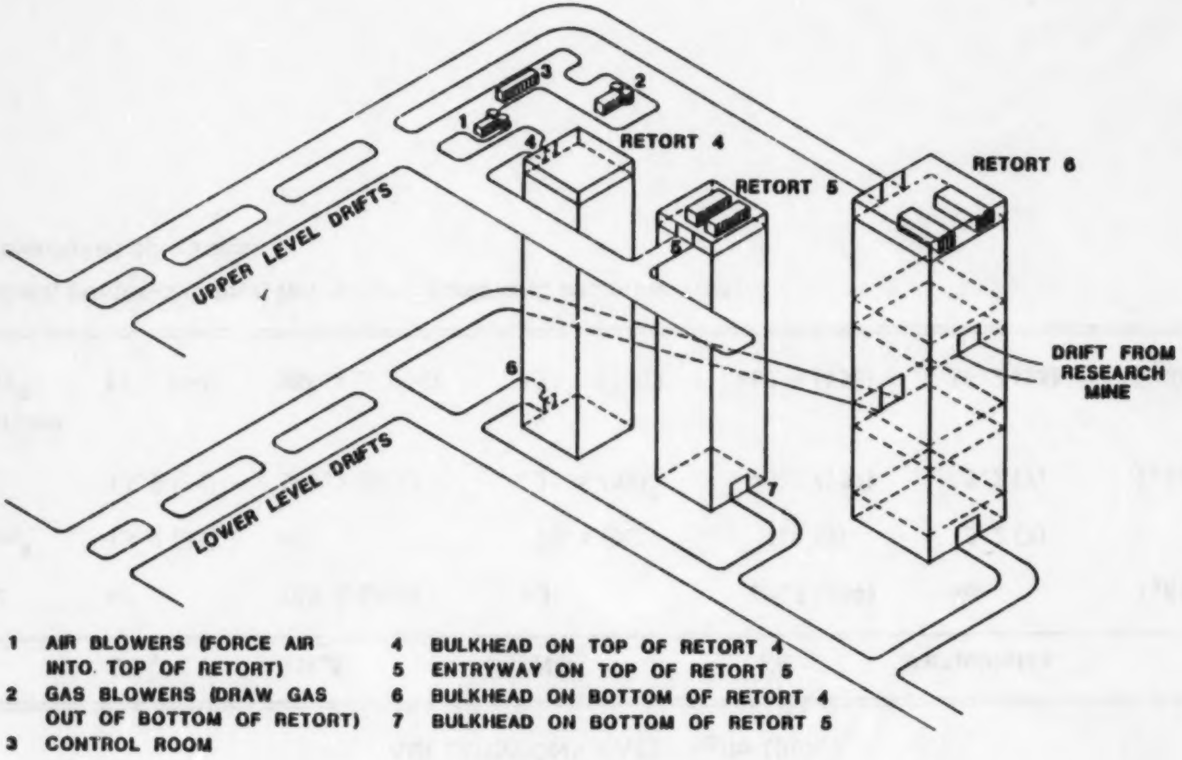

RETORT 4
RETORT 5
RETORT 6
UPPER LEVEL DRIFTS
LOWER LEVEL DRIFTS
DRIFT FROM RESEARCH MINE
1
2
3
4
5
6
7
1 AIR BLOWERS (FORCE AIR INTO TOP OF RETORT)
2 GAS BLOWERS (DRAW GAS OUT OF BOTTOM OF RETORT)
3 CONTROL ROOM
4 BULKHEAD ON TOP OF RETORT 4
5 ENTRYWAY ON TOP OF RETORT 5
6 BULKHEAD ON BOTTOM OF RETORT 4
7 BULKHEAD ON BOTTOM OF RETORT 5

Figure A - 9. Schematic of Occidental's Modified In Situ test.

TABLE A-8. OXY LOGAN WASH RETORTS 7 & 8
AIR EMISSIONS RATES kg/hr (lb/hr)

Location	SO_2	H_2S	NO_x	HC	Particulates	CO
Retort stack	nil	169.2 (376)	nil	69.3 (154)	nil	1,638 (3,640)
Other sources[a]	13.9 (31)	nil	23.4 (52)	1.4 (3)	3.2 (7)	.9 (2)
Total	13.9 (31)	169.2 (376)	23.4 (52)	70.7 (157)	3.2 (7)	1,638.9 (3,642)
Total tonnes/year (tons/year)[b]	81 (90)	986.4 (1,096)	135 (150)	410.4 (456)	16.2 (18)	9,551.7 (10,613)

[a] Includes boilers, heater-treaters, hot water circulators, and mine vent.

[b] Based on 8 months of operation.

and cost estimate of a 340-tonne/day (2,500-bbl/day) technical feasibility plant was performed by Occidental.

Phase II originally involved construction and operation of the 340-tonne/day demonstration plant at Tract C-b, contingent upon receipt of the necessary approvals and construction permits. Phase II was modified to consist of operating Retorts 7 & 8 at the D. A. Shale property because of project schedule delays at Tract C-b.

GEOKINETICS, INC.

On July 22, 1977, Geokinetics, Inc., signed a contract with the U.S. Energy Research and Development Administration (now part of the DOE) for development of a horizontal in situ process. The process involves high-explosive fragmentation of very shallow oil shale deposits followed by in situ retorting with a horizontally moving fire front. A conceptual diagram is shown in Figure A-10.

The work covered by the $9.2-million contract involves Phases III through VI of the project and is expected to last five years. Phases I and II were already completed by Geokinetics in laboratory and field work extending back to 1973. The project site is located in Uinta County, Utah, the site of earlier field work by Geokinetics.

From July 1975 through September 1978, 19 retorts have been drilled, 18 have been blasted, and 11 have been burned. Geokinetics' recovery rate is 50 percent or more of the in-place shale oil. Development of each retort has progressed in five distinct steps, as follows:

- Drilling and blasting-This step included a pre-blast site evaluation including topographic survey and core-hole analysis. New or existing blasting configurations were designed to produce the desired formation porosity. Surface displacement targets were filmed during blasting, and a post-blast topographic survey was conducted.
- Re-entry drilling-Re-entry holes were drilled following the blasting to evaluate the condition of the retorting and overburden zones. Additional holes for combustion air, product gas recovery, production holes, and instrumentation holes were also be drilled.
- Burn preparation and air injection tests-Surface equipment required to conduct the combustion step were installed, and air flow and tracer studies were run to determine the porosity of the retort zone.
- Ignition and burn-The retort was ignited with burning charcoal, and the air rates, retort temperatures, pressures, and product off-gas rates were monitored and controlled where necessary. Oil and water production rates and analyses were also recorded.
- Post-burn examination-The retorts were re-entered or cored as necessary to evaluate the degree of rubblization and pyrolysis occuring in the retort zone. (Since many of the retorts were covered by a thin

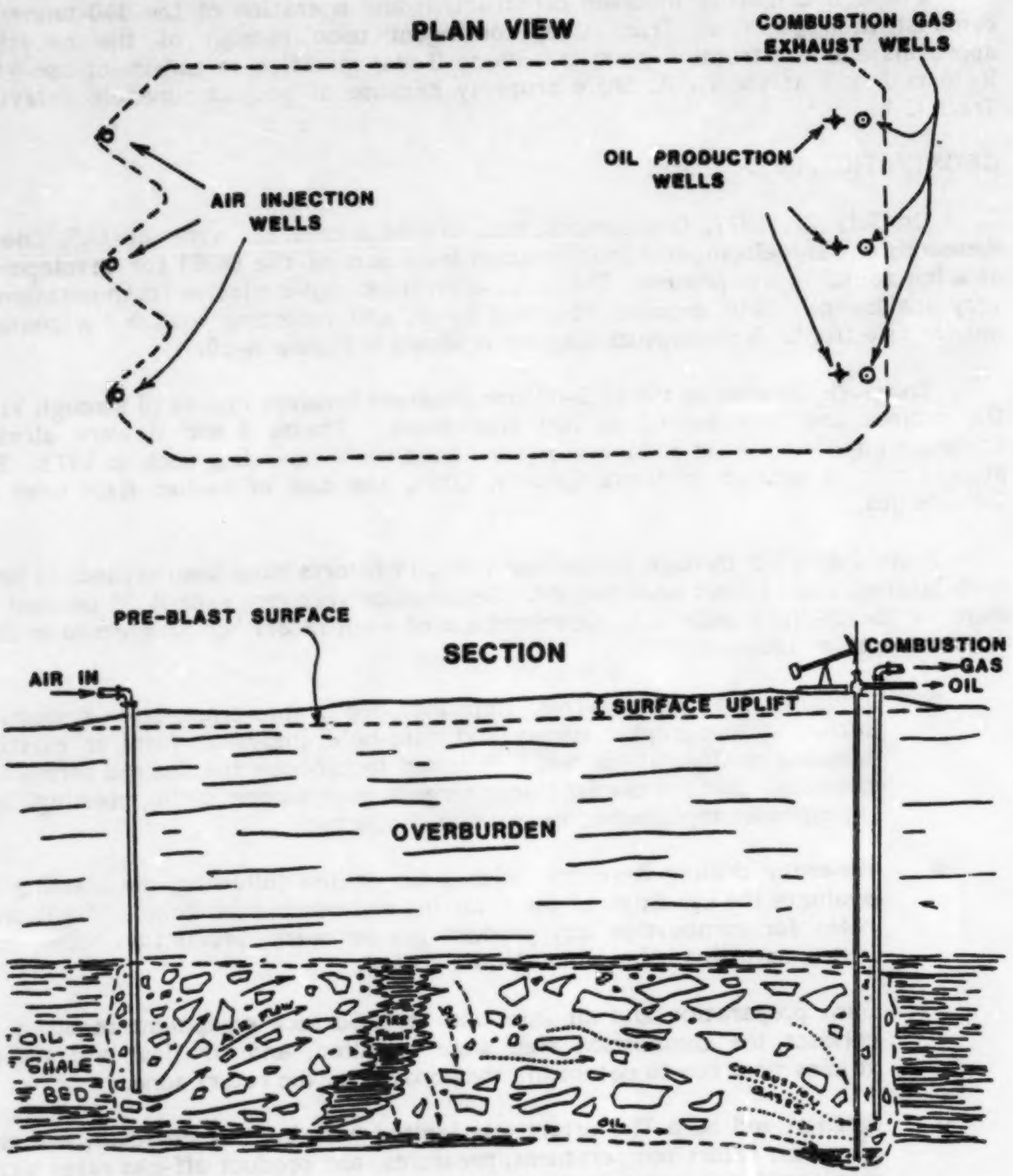

PLAN VIEW
COMBUSTION GAS EXHAUST WELLS
OIL PRODUCTION WELLS
AIR INJECTION WELLS
PRE-BLAST SURFACE
SECTION
COMBUSTION
GAS
OIL
AIR IN
SURFACE UPLIFT
OVERBURDEN
OIL SHALE BED
AIR FLOW
FIRE FRONT
GAS
COMBUSTION GASES
OIL

Figure A - 10. Plan and section of a typical Geokinetics horizontal in situ retort.

(Source: Reference 22.)

layer of overburden, access was attained by digging axial surface trenches with a bulldozer and backhoe).

Rubblization is achieved by detonating explosives within a pattern of blastholes, whereupon the overburden is lifted. The bottom of the retort is sloped to provide drainage into a sump from which product shale oil is pumped. Air injection holes and offgas holes are drilled at opposite ends of the rubblized zone. The oil shale is ignited at the air injection wells, and air is injected to establish and maintain a burning front that occupies the full thickness of the fragmented zone. As the front moves towards the offgas wells, oil shale ahead of the front is pyrolized and product oil drains to the sloping bottom of the retort to the production wells. Residual coke in the spent shale provides fuel for the burn front, the progress of which is monitored by thermocouples set in wells.

As part of the scope of work, a number of environmental parameters are being monitored. These include hydrology, meteorology, air quality, gaseous emissions, biological and health effects, effects on land and reclamation, and societal influences.

In addition to varying retorting parameters to achieve optimum shale oil recovery, in the remainder of 1979 Geokinetics plans to burn a retort within the full 9.3 m (30 ft) thickness of the oil shale bed. A full-sized retort of 62 m by 62 m by 9.3 m (200 by 200 by 30 ft) will be blasted.

In 1980, rubblization of a cluster of three full-sized retorts is planned. This cluster will be burned in 1981, and a second three-retort cluster will be burned during 1981 and into 1982.

The overall program objective of developing and testing the process is expected by mid-1982. If technical, environmental, and economic results are favorable, Geokinetics hopes to construct a full-scale operating unit producing a minimum of 272 tonne/day (2,000 bbl/day) (22).

EQUITY OIL CO.

The Equity Oil Co. entered into a cooperative agreement with the U.S. Energy Research and Development Administration (now DOE) in May 1977 to conduct a 55-month, $6.5 million project to evaluate the technical feasibility of a new in situ shale oil production technology. The project will be conducted on Black Sulfur Creek in the Piceance Creek Basin of Colorado and will involve injection of superheated steam into the leached zone to retort oil shale in situ.

Equity's project is divided into four tasks: leached zone site evaluation, laboratory experimentation, field project work, and an enviromental research program. Site evaluation efforts will include the drilling and coring of two wells through the entire leached zone adjacent to existing wells used by Equity in previous field experiments. The cores will be visually inspected for evidence of retorting, continuity will be marked, and an estimate will be made of void volume. Fischer assays of specific intervals of the cores will be conducted. Tests will be performed to determine if sufficient permeability exists in the two wells. An alternate site may be selected if the permeability at the present location proves to be unacceptable.

The laboratory experimentation will include bench-scale tests designed to simulate in situ retorting of oil shale in the leached zone to provide operational data on the effects of steam pressure, temperature, and flow rate. The data will be used to modify and improve the mathematical model, which will in turn be used to design and optimize the field tests.

The field test involves eight injection and five production wells oriented in a .4 ha (1-acre) pattern, as shown in Figure A-11. The production target will be the 168-m (550-ft) thick leached zone. Because of the relatively low permeability of the center of the formation, superheated steam will be injected into two levels at the rate of 16.1 million kcal/hr (64 million BTU/hr), at a maximum pressure of 102 kg/cm^2 (1,450 psig), and a minimum temperature of 449°C (840°F). Figure A-12 shows a cross section of the process. A two-year injection period is forecast, to be followed by a post-operation corehole program to evaluate the extent of retorting that was achieved. Efforts through the end of 1978 consisted primarily of constructing the surface facilities and drilling the process and instrumentation wells.

The environmental research program will provide for the collection, evaluation, and reporting of environmental data for the following:

- Hydrology and water resources of the experimental areas of influence
- Meteorology and air quality of the areas of influence
- Biological and health effects
- Effects on the land and reclamation
- Societal influences
- Generation of research data for operating permits.

MULTI MINERAL PROJECT

Multi Mineral Corp. (MMC), a subsidiary of the Charter Oil Co., has developed the "Integrated In Situ Process," which would produce raw nahcolite, shale oil, fuel gas, alumina, and soda ash in one integrated operation. In April 1979, MMC, the USBM and BLM signed an agreement which permits MMC to conduct a one-year experimental mining program at the USBM Horse Draw Facility in the Piceance Creek Basin. This agreement also includes a second year process testing program to be considered for approval after the completion of an Environmental Impact Statement which is currently being prepared. Upon completion of the experimental program, MMC hopes to enter into a three-year cooperative agreement with DOE and DOI to construct and test a full scale module of the Integrated In Situ process. Upon successful completion of this phase, MMC would bring the plant to commercial production of 4,500 to 9,000 tonne/day (5,000 to 10,000 ton/day), raw nahcolite, 6,800 tonne/day (50,000 bbl/day) shale oil, 900 tonne/day (1,000 ton/day) alumina, and 4,535 to 9,000 tonne/day (5,000 to 10,000 ton/day) soda ash in two additional years.

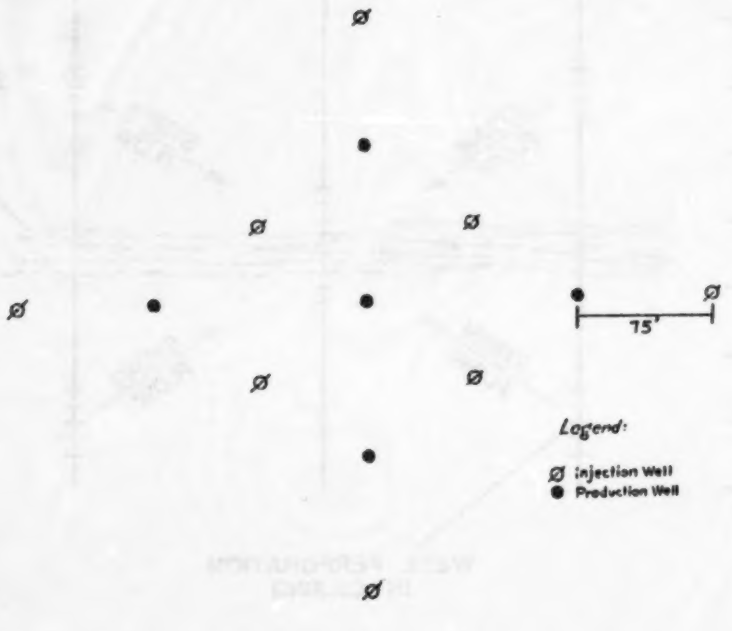

75'
Legend:
Ø Injection Well
● Production Well

Figure A - 11. Well layout of Equity in situ test.

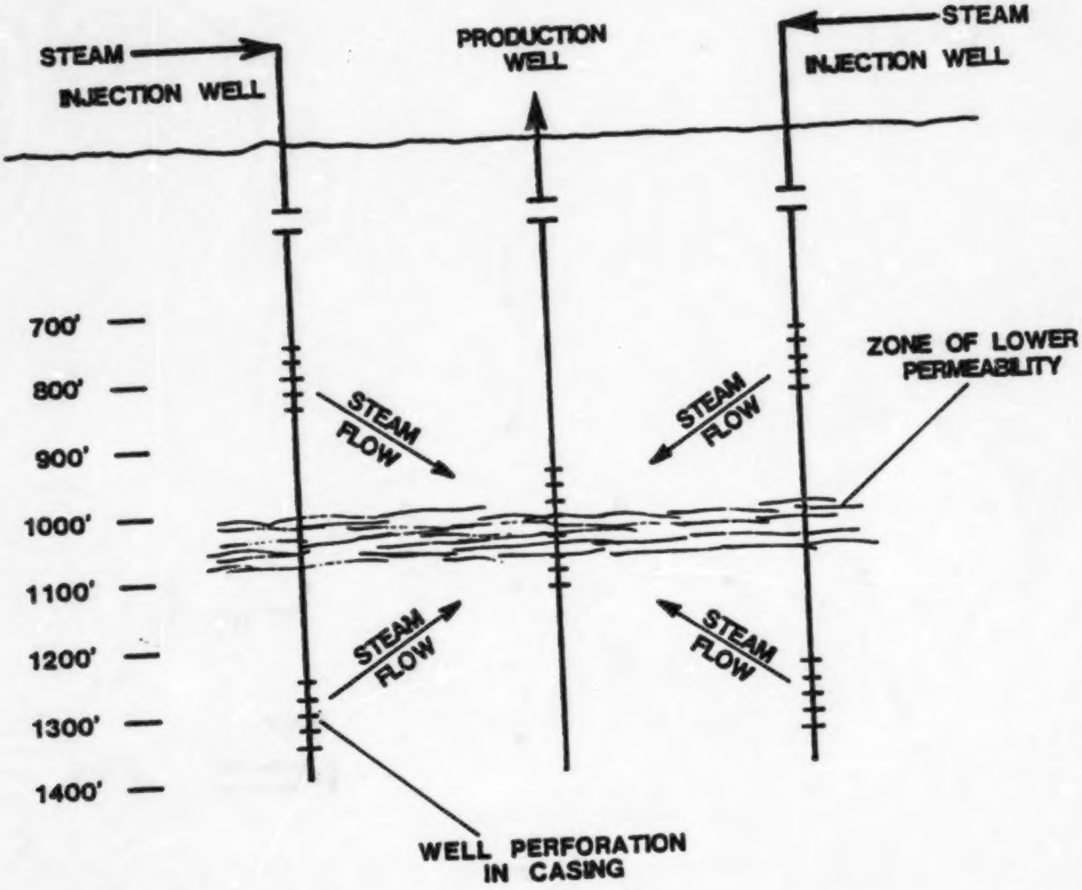

STEAM
INJECTION WELL
PRODUCTION WELL
STEAM
INJECTION WELL
700'
800'
900'
1000'
1100'
1200'
1300'
1400'
STEAM FLOW
STEAM FLOW
STEAM FLOW
STEAM FLOW
ZONE OF LOWER PERMEABILITY
WELL PERFORATION IN CASING

Figure A - 12. Equity well completion cross section.

The experimental mining program has two fundamental objectives: to acquire the geotechnical data on which commercial mining feasibility can be determined, and to bulk-sample the nahcolite-dawsonitic oil shale horizons to provide material for process plant engineering design. The first specific target in the plan is to obtain a 4,535-tonne (5,000-ton) sample of 80 weight percent nahcolite product, which will be done by excavating a test room in a bedded nahcolite horizon on the 570.4 m (1,840 ft) level. The second specific target is to excavate a stope block within a lower nahcolite-dawsonite shale horizon to obtain experience and confirm design data in blasting, pillar design, and rock stability in high-wall openings. This work follows a rock mechanics program of investigation, which simultaneously will produce some 13,605 tonnes (15,000 tons) of ore for processing research and evaluation.

Project Description

The Multi-Mineral Integrated In Situ Process consists of three steps: underground mining and nahcolite recovery, retorting and hydrocarbon recovery, and leaching and soda ash/alumina recovery. The process involves creating large underground chambers (stopes) by sequential blasting and removal of the oil shale from the stope. Gravity flow extraction is through funnel-like openings at the base. The stopes are separated by walls of unbroken oil shale. Their dimensions are variable, depending on the rock character and zone thickness. Extracted oil shale is crushed and screened into two sizes with the larger size being backfilled into the stope. The smaller size is then crushed and screened to separate nahcolite from the oil shale. Rejects from this operation are stored on the surface for future processing.

After backfilling with the top size, the stopes, full of sized oil shale, become underground retorts. The oil shale is retorted by hot gas introduced into the top of the retort and extracted at the base. The shale oil formed, along with the pyrolysis gas and water, is directed to a collection sump where the oil, water and gas are separated. After the oil shale has been retorted, residual carbon is left on the spent shale. The carbon is converted into a low-to-medium BTU gas which will be used for onsite electrical power generation.

After the shale in the retort is cooled, soda ash and alumina are leached from the stope by spraying water over the top of the retorted shale and collecting this water as pregnant liquor at the base. This can be done in more than one stope simultaneously in a countercurrent process. The pregnant liquor is then pumped to the surface for recovery of the alumina and soda ash.

Emissions, Effluents, and Solid Wastes

MMC has not prepared an assessment of the impacts related to a commercial complex. An EIS is expected to be required on this project because of the nature of the land acquisition. Approval of such a statement should not pose the major constraint facing other in situ projects, specifically degradation of subsurface water by leaching of spent shale left underground after retort abandonment. Reason for this is that the mining will be done in the Saline Zone where the oil shale beds are relatively dry and unfractured. If water in encountered, the stopes can be sealed using the mining access ways constructed during stope development. No outside source of water will be required in this process. Make-up water for processing will be supplied from the Leached Zone.

DOW CHEMICAL CO.

Dow Chemical signed a contract with the U.S. Energy Research and Development Administration (now DOE) in March 1977, to conduct a program to test the feasibility of in situ processing of Antrim shale. The 48-month contract is valued at roughly $14 million and will be conducted on a 32-ha (80-acre) site which Dow owns in fee near the Midland, Michigan plant.

The program includes four tasks, as follows:

Task 1 - Shale characterization
Task 2 - In situ fracturing and assessment
Task 3 - In situ extraction trials
Task 4 - Environmental, public policy, and legal assessment

Task 1 is aimed at characterization of the Antrim shale both as to its geochemical, lithological, and physical properties, and also its physical extent. Included in this task will be a corehole drilling project in which three coreholes of 10 cm (4 in.) or larger diameter will be drilled on the Dow property. The coreholes will provide samples from the overburden and underlying formations as well as from the Antrim shale formation. Core and well cutting samples from other sources such as the University of Michigan sample library will also be analyzed whenever possible. In assessing the resource inventory, a number of maps will be prepared that show the extent of the Michigan Basin Antrim shale formation.

Task 2 of the project involves evaluation of three in situ fracturing methods. First, two wells will be drilled approximately 61 m (200 ft) apart to a depth of about 427 m (1,400 ft). These two wells will then be hydraulically fractured, sand-propped, and refractured with chemical explosives. Once the extent and direction of fracturing has been determined, four additional wells will be drilled and cored to intercept the induced fracture system. The system will then be subjected to comprehensive testing to determine permeability to gas flows between wells. A second fracturing technique will use acid leaching of limestone stringers at the base of the Antrim shale, followed by secondary fracturing with chemical explosives. This central acid-leached well will be surrounded by up to six injection/production wells that intercept the fracture system. The final rubblization technique evaluated will be explosive under-reaming in which successive shots with chemical explosives followed by well-bore cleaning are used to produce a rubblized shale cavity. This well will also be surrounded by up to six injection/production wells. In all cases, the permeability between wells through the fracture system will be evaluated.

To date, Dow has completed orientation coring, air injection tests, and renovation of the original Dow in situ site. Experiments are being conducted on conventional hydrofracing, chemical underreaming, and explosive underreaming. In the chemical under-reaming tests, notching of the limestone stringers was achieved and this is to be followed by a hydrofrac procedure. An evaluation is also being conducted to determine if plans for a scheduled post-acid treatment seismic monitoring can be modified so as to determine the extent of the present fracture system.

Task 3 will involve in situ production of oil and gas at the test site. Initially, production will be attempted on a test site that has already been developed by Dow. If retorting is successful, operations will be continued for up to six months, and material and energy balances will be made on all materials injected and products recovered. The production period will be followed by a six-month observation period in which any above or below ground changes will be monitored. This will be followed by coring at the site to determine the extent of resource utilization. When this information has been analyzed, one of the three test sites developed under the DOE contract will be selected for an additional extraction trial.

Finally, Task 4 of the project will evaluate the environmental impacts of the in situ project as well as determine the public policy and legal constraints that might apply to commercial processing of the Antrim shale.

LARAMIE ENERGY TECHNOLOGY CENTER

The Laramie Energy Technology Center (LERC) has been conducting field tests on in situ production of shale oil since 1966. Much of the work has involved evaluation of various fracturing techniques aimed at increasing formation porosity and permeability. Various combinations of electrofracing, nitrofracturing (using nitroglycerin as the fracturing explosive), explosive fracturing using slurry explosive, hydrofracing, and acid leaching have been tried in experiments conducted at the project site near Rock Springs, Wyoming. Several combustion tests using air injection have been tried, but with limited success. Although sustained combustion was accomplished over extended periods only a small portion of the oil calculated to have been retorted was able to be recovered through the production wells.

In Situ Site No. 1 was first drilled for tests of electrofracing experiments near Rock Springs. The results of these tests were inconclusive because the formation was found to contain substantial natural porosity as a result of a 5-cm (2-in.) layer of volcanic tuff. The site was also used for preliminary tests of nitrofracing in which 47.3 liters (50 quarts) of nitroglycerin was injected into the naturally permeable zone and detonated. Significant increases in formation permeability were observed following detonation.

Both electrofracing and nitrofracing experiments were conducted at In Situ Site No. 2. The results of the electrofracing tests indicated that electrofracing was accomplished at all electrode spacings used, ranging from 1.2 to 37.8 m (4 to 124 ft). After the electrofracing phase was evaluated, the fractures were subjected to a series of nitrofracing experiments in which conventional well bore shots of nitroglycerin were detonated at levels corresponding to electrode positions during the electrofracing test. Air flow between boreholes increased appreciably after the shots. Two in situ recovery experiments were tried on Site No. 2. The first consisted of the injection of 7 kg/cm^2 (100 psig) steam superheated to 650 to 704°C (1,200 to 1,300°F). The formation plugged after one day of injection, and the steam approach was abandoned. The second experiment consisted of the injection of a heated inert gas. The gas (diesel engine exhaust) passed through a combustion catalyst and was then compressed before injection at 650 to 760°C (1,200° to 1,400°F). This injection was run for a two-week period with a cumulative recovery of about one gallon of oil, and the run was terminated.

In Situ Site No. 3 was subjected to a series of nitrofracing tests that were successful in improving the formation porosity. No combustion evaluation was made at this site.

Electrofracing, hydrofracing, and nitrofracing tests were conducted at In Situ Site No. 4 to improve formation porosity. While electrofracing was not successful in creating additional permeability, hydrofracing and nitrofracing did create substantial porosity at the five-spot formation.

At the conclusion of the fracturing tests, Site No. 4 was subjected to combustion evaluation. This evaluation was essentially successful, in that significant quantities of gas and oil were recovered. A total of 25.8 tonnes (190 bbl) of shale oil was recovered. An analysis of the combustion project revealed that approximately 97 tonnes (714 bbl) of shale oil had been produced. It was estimated that a total of 1,062 tonnes (7,810 bbl) were present on the site.

In Situ Site No. 6 covered an area of approximately 45.7 by 91.4 m (150 by 300 ft) and included a 55-well pattern. The oil shale formation at Site 6 was electrofraced and then explosively fractured to increase the permeability of the formation. A 49-week combustion test at Site No. 6 was conducted without recovering any significant amount of oil. At the conclusion of the test, it was decided that the energy used in initiating the combustion experiment was so widely dissipated that very little oil shale reached retorting temperature.

The primary objective of the In Situ Site No. 7 experiment was to study problems associated with ignition of oil shale broken by hydraulic fracturing and by detonation of explosives in well bores. The combustion phase of the test began in April 1970 and was terminated as soon as it was established that the oil shale had been successfully ignited.

In Situ Site No. 8 was used to evaluate electrolinking and acid leaching of the resulting fractures. No combustion experiments were conducted at this site.

Initially, In Situ Site No. 9 involved a 9-spot well pattern that was hydraulically fractured, followed by explosive fracturing with slurry-type explosives. The oil shale bed was ignited on April 5, 1976. During 150 days of combustion, it was apparent that considerable amounts of shale were being retorted underground. However, repeated failure of the oil production wells, because of mechanical problems resulted in only minimal recovery of shale oil. It was felt that considerable quantities of shale oil had migrated past a production well, hence three additional wells were drilled outside of the original pattern in an attempt to intercept some of the produced shale oil.

Material balances at the site following the combustion experiment revealed that of the 1,061 tonnes (7,800 bbl) of oil available, 147 tonnes (1,080 bbl) were produced; however, only 8.2 tonnes (60 bbl) of shale oil were recovered.

Present work at the Rock Springs site involves using a combination of steam and air injection at In Situ Site No. 12. Phase I involves a basic two-hole test to gather information for modeling before a bigger burn, which will be conducted at an adjacent site. Ignition was begun at Site No. 12 in November 1978.

Future work will involve the use of large-diameter boreholes, under-reaming, hydraulic mining, and possible other techniques in combination with slurry explosives as a means of obtaining sufficient porosity and permeability to conduct in situ retorting. These fracturing methods will provide more volume for explosives and will provide a free surface to facilitate rubblization by blasting.

Much of the data that aided LERC in conducting of the field tests discussed above were acquired under controlled conditions at the Laramie facilities. In addition to much laboratory equipment that may be used to simulate in situ retorting, LERC also has 9-tonne (10-ton) and 136-tonne (150-ton) N-T-U retorts available for testing. Since this aboveground process closely resembles a vertical underground retort, data obtained from the N-T-U retorts can provide a better understanding of the processes occurring in the in situ operation.

Extensive environmental monitoring is being conducted in conjunction with the Rock Springs retorting tests. Water quality and quantity are monitored with both wells and surface stations, and the chemical composition of the groundwater will be analyzed before, during, and after retorting to determine chemical changes. Air sampling is being conducted, including stack-gas sampling and an on-line gas chromotograph for gas analysis.

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APPENDIX B

PROCEDURES FOR AMBIENT AIR MONITORING

INTRODUCTION

This appendix provides an expansion upon the discussion of the sampling and analysis techniques for ambient air monitoring presented in Section 5 of Volume 1. This discussion is by no means complete and extensive research into the individual method is required before it is selected or used. In the rural areas generally characteristic of the oil shale areas, ambient values may fall below the detection limits of the EPA reference or equivalent methods. For this reason, alternate methods have been presented even when a Federal reference method or equivalent method exists. A summary of the methods presented in this section is provided in Table B-1. The EPA reference and equivalent methods are summarized in Table B-2.

METEOROLOGICAL MEASUREMENTS

Meteorological information is critical for the assessment of environmental impact resulting from new source emissions. It is essential that meteorological data be representative of source conditions and primary receptor areas. The degree to which the data are representative depends on complexity of the terrain, exposure of the sensors, and the period of data collection. Although onsite data are preferred, offsite data may be adequate for some applications (1). A minimum of 1 year of meteorological data is required. If available, 5 years of data should be used to minimize year-to-year variations.

Most meteorological parameters can be measured using standard National Weather Service (NWS) equipment or its equivalent, and data values should meet either NWS or EPA standards for accuracy. For certain applications (such as some complex terrain models) higher quality equipment may be required. The parameters measured depend on previous data available for the area, representativeness of that data, and its intended application. Extensive information exists on required meteorological inputs for standard computer air monitoring models and guidelines on meteorological siting and instrument exposure. Data averaging over time periods shorter than 1 hr is required for complex terrain modeling.

In addition to the parameter and siting requirements, meteorological measurements should meet certain basic accuracy requirements. A number of the common meteorological parameters and their corresponding EPA accuracy values are listed below (2):

TABLE B-1. SUMMARY OF METHODS PRESENTED

Parameter and Methods	Manual or continuous	Range
SO_2:		
Colorimetric[a]	Manual	5 to 13000μg/m^3
Flame photometric[b]	Continuous	26 to 2600μg/m^3
Pulsed fluorescent	Continuous	13 to 1300μg/m^3
NO_2:		
Colorimetric	Manual	9 to 752μg/m^3
Chemiluminescent[a]	Continuous	9 to 1880μg/m^3
Ozone:		
Chemiluminescent[a]	Continuous	10μg/m^3 to 2mg/m^3
UV photometric[b]	Continuous	6 to 1960μg/m^3
Particulates:		
Hi-Vol[a]	Manual	10 to 1000μg/m^3
Stacked filter	Manual	
Dichotomous	Manual	
CO, CH_4, non-methane hydrocarbons:		
Nondispersive infrared[a]	Continuous	28 to 1150μg/m^3
Gas chromatography	Semi-continuous	16 to 1300μg/m^3
Ammonia:		
Colorimetric	Manual	20 to 700μg/m^3
Chemiluminescent	Manual	

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[a] Federal reference method.

[b] Equivalent method.

(continued)

TABLE B-1 (Continued)

Parameter and Methods	Manual or continuous	Range
H_2S, mercaptans, organic sulfides:		
Flame photometric	Manual	0.001 to 1.0 ppm
Sulfates:		
Methylthymol blue (hi-vol)	Manual	.6 to 19μg/m^3
Nitrates:		
Cadmium reduction (hi-vol)	Manual	.03 to 7.4μg/m^3
Lead:		
Atomic absorption (hi-vol)	Manual	.03 to 7.5μg/m^3
Mercury:		
Atomic absorption (silver wool)	Manual	5 to 500μg/m^3
Atomic absorption (cold vapor)	Manual	.015 to 10μg/m^3
Arsenic:		
Atomic absorption (hi-vol)	Manual	0.1 to 1μg/m^3
C_1-C_5 hydrocarbons:		
Gas chromatography	Manual	>.01 ppm
B α P:		
Fluorometric (hi-vol)	Manual	0.02 to 0.8μg/m^3
PAH:		
GC and UV spectroscopy	Manual	2 to 1000μg/m^3
POM:		
GC and flame ionization detection	Manual	0.05 to 10mg/m^3
GC and mass spectrometry	Manual	>0.1 ng/m^3

TABLE B-2. EPA Reference and Equivalent Methods Designated as of December 21, 1978

	Manual	Automated	
	Equivalent	Reference	Equivalent
SO_2	1. Technicon I 2. Technicon II		1. Lear Siegler SM1000 2. Meloy SA185-2A 3. Thermo Electron 43 4. Philips PW9755 5. Philips PW9700 6. Monitor Labs 8450 7. ASARCO 500 8. Beckman 953 9. Bendix 8303 10. Meloy SA285E
CO	---	1. Bendix 8501-5CA 2. Bechman 866 3. MSA 202S 4. Horiba AQM-10, 11, &12	---
O_3	---	1. Meloy OA325-2R 2. Meloy OA350-2R 3. Bendix 8002 4. McMillan 1100-1 5. McMillan 1100-1 6. McMillan 1100-3 7. Monitor Labs 8410E 8. Beckman 950A	1. Dasibi 10003-AH, 1003-PC 2. Philips PW9771
NO_2	1. Sodium Arsenite 2. Sodium Arsenite/ Technicon 3. TGS-ANSA	1. Monitor Labs 8440E 2. Bendix 8101-C 3. CSI 1600 4. Meloy NA530R	---

- **Wind speed: Accurate to 0.25 m/s (9.8 in./sec) from the threshold of 0.5 (19.6 in./sec) to 5 m/s (196.8 in./sec). Above 5 m/s (196.8 in./sec), less than 5 percent error, not to exceed 2.5 m/s (98.4 in./sec) error.**
- **Wind direction: Less than 3° of true 10-min average.**
- **Temperature: Error less than 1.0°C (1.8°F).**
- **Dew point temperature: Error less than 1.0°C (1.8°F).**
- **Temperature difference: Error less than 0.003°C/m (5.4×10^{-3}°F/m).**
- **Radiation (solar and terrestrial): Accuracy of ± 5%.**
- **Mixing height: Same accuracy as NWS radiosonde.**
- **Precipitation: Error less than 0.25 mm (9.8×10^{-3} in.) liquid precipitation per hour.**

VISIBILITY

The Clean Air Act Amendments of 1977 declared the protection of visibility in mandatory Class I Federal areas as a national goal. The NAAQS and PSD standards require that a means of maintaining visibility in such areas be developed. During 1979, EPA will submit a report to Congress defining visibility, monitoring methods, modeling data requirements, and permit review requirements. This report will provide the guidelines required to establish regulations.

At this time, no universally accepted definition of visibility or visibility monitoring methodology exists. However, four common methods for assessing visibility related parameters appear promising and are likely to be included in the report to Congress: (1) photography, (2) telephotometry, (3) nephelometry, and (4) transmissometry (3).

Photography

Photography has been used for some time in assessing visibility. A photograph of a scene is used to document visibility, and it can be evaluated qualitatively to determine the degree of visibility degradation or to compare different scenes and areas. Knowing the relationship between radiance and optical density of the film, an operator can use a densitometer to measure the contrast between a target and the horizon. This contrast can be related to the response of the eye in determining a visual range.

Quantitative contrast measurements using photographs require extensive quality control. The relationship between film optical density and radiance must be evaluated for each type of film emulsion used. This relationship can also be altered by the developing process. To help normalize this effect, a standard control object should be photographed on each type of film. Lighting conditions, such as sun angle or cloud cover, also have a significant effect on visual ranges determined at different times and physical locations.

Telephotometry

The telephotometer employs the same basic principles as photography. A portion of an entire scene is viewed through a telescope. Instead of using film to record the amount of light received from the target and horizon sky, a telephotometer measures it directly. The ratio of target to horizon radiance can be measured to ± 1 percent. Color filters may be inserted to measure the amount of light received in various wavelengths and used to assess both visual range and color alteration.

Like photography, this method measures visibility over a long path, but it is limited exclusively to daylight hours. It is also affected by lighting conditions such as sun angle and cloud cover, which must be taken into account when data from different times or locations are compared.

Nephelometry

The integrating nephelometer is used to measure the scattering coefficient of an air sample collected at a single location. The air sample is drawn into a chamber and illuminated by a light source. Photodetectors then measure the light scattered by the sample. The resulting scattering coefficient is related to visual range by means of a model. In Class I areas, a nephelometer capable of measuring scattering coefficients of $10^{-5}m^{-1}$ or less will be required.

The nephelometer has the advantage of being insensitive to exterior lighting conditions and targets; however, it is a point measurement. Therefore, data interpretation must assume a homogeneous distribution of aerosols in the local atmosphere. The effect of absorption by atmospheric pollutants upon observed visual range is not measured by this principle.

The integrating nephelometer can be calibrated using filtered air or Freon-12, or by introducing a scattering medium of known characteristics. Calibration should be frequent in order to assess the amount of zero point drift. This is especially critical in the pristine West, where background concentration measurements tend to approach the detection limits of commercial nephelometers. It is also necessary to ensure that the humidity inside the nephelometer is equal to ambient humidity, since changes in humidity will result in changes in the scattering coefficient measured. A properly maintained and operated nephelometer can measure the scattering coefficient with an accuracy of ± 1 percent.

Transmissometry

A transmissometer measures the attenuation (absorption plus scattering) of light by the atmosphere. The device consists of an intense light source and a photodetector. Light from the source passes through the atmosphere, where scattering and absorption take place, and is focused on the photodetector. This measurement of attenuation is related to visual range by means of a model. Errors using this method are dependent on the path length of the transmissometer. In the pristine West, a path length of at least 2.5 km (1.5 mi) is required to compute visual ranges to within ± 10 percent. As the path length increases, the effects of atmospheric turbulence become more significant. At present, transmissometers have not been developed to perform consistent measurements over long paths.

SO_2 METHODS

Colorimetric Analysis

Based on the Schiff reaction and West-Gaeke modifications, sulfur dioxide is absorbed from ambient air volumes by a solution of potassium tetrachloromercurate (TCM). The resulting dichlorosulfitomercurate complex is reacted with pararosaniline and formaldehyde to form a colored dye. Absorbance of this colored solution is measured spectrophotometrically (4). The EPA reference method is given in the Code of Federal Regulations (5) and is called either manual or automated. A revised standard of test also appears in the ASTM Book of Standards (6).

The method has application in the ambient atmospheres in the range from 5 to 13,000 $\mu g/m^3$ (0.002 to 5 ppm). Autoanalyzer techniques, absorption collection efficiency of sampling, and manipulation of sample solution aliquot have lowered the limit of detection to $5 \mu g/m^3$ (7-9).

Sampling is accomplished by passing a calibrated volume of air through the absorbing reagent while protecting it from both direct sunlight and temperatures greater than 25°C (77°F). Samples solutions that are stored must be kept at a reduced temperature 0°C (32°F).

Multipoint μg SO_2 versus absorption calibration curves are required in the analysis procedure when samples are received, following an analyzer malfunction, or when control limits exceed 0.03 ± 0.002 absorption units/μg SO_2. Calibration should occur in the concentration range of 0.01 to 0.5 ppm in remote ambient areas. Freeze-dried reference materials equal to about 8 to 60 μg (.003 to .024 ppm) of SO_2 in TCM have been used in EPA audits nationwide to examine performance. Within laboratory precision has been reported at 4.6 percent (10). Audit performance measurement of SO_2 by EPA shows that there is no apparent bias between the manual and automated methods, though the standard deviation is lower for the automated method. Of 143 laboratories participating in the audit, the average percent difference between reported and EPA results was 13 percent (6 $\mu g/m^3$ or .0024 ppm) (11).

Flame Photometric Detection

Ambient air is sampled continuously and supplied to a flame photometric detector. An in-line H_2S scrubber is required by the equivalent method under designation by the U.S. EPA. SO_2 is converted to an excited molecular species that emits light near the 394 nanometer (nm) wavelength. The intensity of this light is measured with an optically filtered photomultiplier tube. Response is approximately equal to the square of sulfur atom concentration (12, 13).

Analyzers that chromatographically separate SO_2 from other gases in ambient atmospheres do not respond to changes in concentration as quickly as those that monitor without prior separation. Concentrations over the range of 0.01 to 1 ppm are measured in atmospheres containing low concentrations of gaseous sulfur and CO_2. Ambient air is sampled at 200 ml/min (12.2 in.^{3}/min) as determined by mass or soap-bubble flowmeter. Properly maintained power and temperature are important to continuous performance within quality control limits (13).

Calibration should be performed weekly. Multipoint concentrations are supplied to the ambient sampling manifold using the same air matrix required by the flame photometric detector employing an NBS traceable SRM or secondary standard. To minimize interference, it is necessary to account for environmental CO_2 when calibration is performed. Performance audits are recommended quarterly. Zero and five-point concentration is measured between 0.05 and 0.45 ± 0.01 ppm. There are no accuracy data for this ambient method for concentrations near the limit of detectability (14).

Pulsed Fluorescent Detection

Ambient air is sampled continuously and supplied to a fluorescent chamber where SO_2 is detected. Pulsating ultraviolet (uv) light is focused through a narrow band pass filter into the fluorescent chamber. SO_2 molecules are excited and fluorescent light is emitted and measured by a photomultiplier tube. The fluorescent radiation is proportional to SO_2 concentrations in ambient air. The method is an EPA designated equivalent method (15).

The method has application where instrumentation is operated on the 0.5 ppm full-scale range within a temperature range of 20° to 30°C (68° to 86°F) and where suitable power is available. Ambient atmospheres with concentrations greater than 5 ppb over a 24-hr period are measured with a rise and fall time of 4 min as concentration is changed. The analyzer samples ambient air at 1.6 to 6.4 l/min (98 to 390 in.^{3}/min), and properly maintained power, ventilation, and temperature are important to continuous performance.

Multipoint concentrations are supplied to the ambient sampling system at a minimum 1.6 l/min (98 in.^{3}/min) flow rate. Dilution air similar in composition to the matrix being measured is recommended to minimize interference bias.

Within-laboratory repeatability or single-station operation is checked with weekly zero and span checks to insure that performance is within the manufacturer's specifications (performance specifications for automated methods for SO_2 are given in the Code of Federal Regulation, Reference 16). Control checks require a precision of ± 0.01 ppm and corrective action if limits exceed 0.025 ppm. Performance audits are recommended quarterly. Zero and five-point span checks at concentrations between 0.05 and 0.45 ± 0.01 ppm should be made.

Impregnated Filter (Promising New Technology)

Battery-powered sampling pumps draw ambient air through filters impregnated with tetrachloromercurate (II). Filter samples are transported to the laboratory for analysis by the West Gaeke colorimetric procedure (17, 18). The method has application in ambient atmospheres of less than 1 ppm SO_2 concentration. Sensitivity has been reported as 0.05 ppbv for ambient air volumes of 1 m^3 (35.3 ft^3). The principle can be applied to areas that do not have power available. Typical applications have been to operate the sample flow rate at about 6 l/min (366 in.^{3}/min) for periods of up to 4 hr. Best results are achieved by co-locating filter samplers at each monitoring site. Samples are transported in sealed petri dishes and placed in a desiccator analysis.

NBS permeation tubes are used to provide test atmospheres of SO_2 for calibration. Efficiency of sampling has been reported at 92 percent for samples with ambient concentrations of 15 ppbv and flow rates of 6.5 l/min (397 in.^{3}/min) (17). Combined analytical and sampling precision at stated efficiency has not been performed. Accuracy data from independent calibration with test atmospheres have not been developed.

CO BY NONDISPERSIVE INFRARED METHOD

The principle of nondispersive infrared (NDIR) is based on the absorption characteristics of CO at infrared wavelengths. The spectrometer measures the absorption of CO using two parallel infrared beams and a selective detector over the range of 1.2 to 115 mg/m^3 (1 to 100 ppm) (19). This procedure is an EPA federal reference method (20).

Application depends on the ambient atmosphere to be monitored, since the degree of interference by water vapor can be equivalent to 11 mg of CO/m^3 (10 ppm) (21). Hydrocarbons at concentrations found in suburban ambient atmospheres do not ordinarily interfere since 325 mg methane/m^3 (500 ppm) will give a response equivalent to 0.6 mg/m^3 (0.5 ppm) (22).

NDIR instruments usually sample continuously at about 0.5 l/min (30.5 in.^{3}/min). Carefully controlled operational environments are required.

Many factors can affect the precision and accuracy of this method (22). Zero and span checks are recommended daily using high quality zero air and span gas cylinders with concentrations over the range of ambient concentrations (in urban areas these ranges are usually 2 to 12 mg/m^3 or 1.7 to 10 ppm). Multipoint calibration should be performed following installation or malfunction and when span changes exceed 2 mg/m^3 (2.0 ppm) with a span concentration between 9 and 12 mg/m^3 (8 to 10 ppm) (23, 24).

Accuracy should be determined quarterly with internal performance audits using different standards and equipment than those used during routine calibration. Analysis can be expected to produce a positive 3 ppm bias due to interferences and uncertainty of calibration gas assay (22).

SUSPENDED PARTICLES BY HIGH-VOLUME SAMPLER

The principle of the high-volume particle sampler is filtration sieving from a moving air stream. The glass fibers collect particles by interception and diffusion mechanisms according to the size of airborne particulate being sampled.

Particles with diameters of less than 100 µm (3.94×10^{-3} in.)(Stokes equivalent diameter) are normally collected over a 24-hr period at a flow rate of 1.1 to 1.7 m^3/min (38.8 to 60.0 ft^3/min). The method is applicable in an ambient atmosphere having concentrations of suspended particulates in the 10 to 1000 µ range (µg/m^3) (3.94×10^{-4} to 3.94×10^{-2} in.)(25). Filter samples (20 by 25 cm or 7.9 by 9.8 in.) are transported to a laboratory for gravimetric analysis using an analytical balance capable of reading to 0.1 mg (2.2×10^{-7} lbs) with a range of about 5 g (1.1×10^{-2} lbs) (26).

The high-volume sampler is oriented into the prevailing wind direction. The large particle collection efficiency (mass dominant fraction) will vary with wind direction (27). Collection efficiency is a function of fiber diameter, and filter efficiency is impaired by protracted periods of sampling in atmospheres containing liquid aerosols (28). Any gaseous substance in the sampled atmosphere that is reactive or absorptive on the filter or its collected matter will introduce artifacts into the gravimetric or chemical analysis of the filter (29).

Calibration requirements include periodic flow measurements with reference materials. The flow rate for each sampling period must be documented to establish that the volume of sampled air is within ± 7 percent of the calibration curve (7), and the time elapsed is within ± 2 min/24 hr.

A correction for barometric pressure change due to altitude is required (22).

Minimum requirements are to check filter weighing weekly. Randomly selected exposed filters must be reweighed to ensure that repeatability is within ± 5 µg (1.1×10^{-8} lbs)(31, 32). Two samplers for each network day must be collected. Between-laboratory precision has been reported at 3.7 percent.

Accuracy of reported TSP data is dependent upon the airflow rate through the sampler and the traceability procedures with NBS class S weights. The assessment of accuracy is made by quarterly audits of the flow and weighing portions of the measurement process.

OZONE METHODS

Ultraviolet Absorption

The principle utilizes the intensity changes of UV energy as the light beam traverses a fixed pathlength occupied by a volume of air containing ozone (33). This method is an EPA equivalent method. Continuous instrumentation utilizing the UV absorption principle will measure concentrations from 6 to 1,960 µg/m^3 (0.003 to 1.0 ppm).

Ambient monitoring is conducted continuously at 2 to 6 mg/m^3 (1 to 3 ppm) continuously in normal configurations (33, 34). Interferences from olefins and sulfides under some operating conditions have been experienced (35). Primary pollutants at ambient concentrations do not interfere with measurement. Areas containing ambient concentrations of mercury require modified sampling procedures.

The signal-generating system from the UV detector is referenced to zero and spans the instrument automatically. External calibration with zero and span is required at least weekly (36). The precision for this method has been shown to be 1.7 percent (37). The accuracy depends on the frequency of calibration. Calibration accuracy and multipoint (5 points) linearity are performed against a separate UV absorption instrument (primary) and an ozone generator once each quarter. This combination should be verified against the boric acid potassium iodide technique for independent calibration. Evaluation of four ozone calibration procedures have shown the UV photometric procedure to have no significant bias and a reproducibility less than or equal to 3.4 percent (38).

Chemiluminescence

Sample gases containing ozone and reagent ethylene are combined, and the resulting chemiluminescent light is photometrically detected (39, 40). This is the Federal reference method for photochemical oxidants. Instrumentation to monitor ozone continuously in the ambient atmosphere is specified in the Federal Register (41). A TFE fluorocarbon sampling probe with an in-line filter element to remove particles from the air stream should be used.

Ambient atmospheres are monitored over the concentration range of 10 µg/m³ to 2 mg/m³ (0.005 to 1.00 ppm). The chemiluminescent detection of ozone with ethylene is not subject to interference from common gaseous air pollutants such as NO_2, CO, NH_3, and SO_2 at ambient concentrations.

An internal factory-calibrated ozone source should be verified weekly by gas phase titration. Zero and span checks between 157 and 196 ± 49 µg/m³ (0.08 and 0.1 ± 0.025 ppm) are required weekly. Test atmospheres of ozone are provided at the inlet at 98, 196, 392, 588, 882 ± 20 µg/m³ (0.05, 0.10, 0.20, 0.30, and 0.45 ± 0.01 ppm) during calibration (37). The precision of chemiluminescent procedures for NO_2 is on the order of 6 percent. Zero and single point span are recommended using an ozone generator that has been calibrated using a boric acid/potassium iodide reference method of UV photometer. Quarterly performance audits by different personnel using different equipment and standards are conducted in a similar manner to assess accuracy (42). A negative bias of 5 percent has been observed in other collaborative testing programs for chemiluminescent procedures (43).

NO_2 METHODS

Colorimetric Analysis

NO_2 is measured by specifically removing NO_2 with sodium arsenite through reactions between nitrite ion (NO_2^{-}) and diazotizing and coupling reagents. Analysis of the colored azo dye is performed with a spectrophotometer at 540 nm of 10 nm bandwidth (44). This is the EPA reference method for NO_2.

The method has application in ambient atmospheres in the range of 9 to 750 µg/m³ (0.005 to 0.4 ppm) using 24-hr samples. Interferences are negligible in ambient air quality monitoring when the procedure is applied in undeveloped areas. NO and CO_2 have been found to be potential interferences in urban atmospheres (45).

Sampling can be conducted continuously with an air flow rate of 200 to 300 ml/min (12.2 to 18.3 in.³/min) (46). Samples are protected from sunlight and stored at reduced temperature (0°C, 32°F).

Calibration is performed using a standard nitrite solution to prepare a calibration curve of NO_2 concentration versus absorption. Six data points are used to construct a least squares fit of data to a straight line. The slope of the line must be 0.48 ± 0.02 absorption units per µg NO_2. Calibration is to be performed when control samples exceed ± 2.2 µg NO_2 or when a new batch of reagents is prepared. Within-laboratory standard deviation is 8 µg/m³ (.004 ppm), and between-laboratory standard deviation is 11 µg/m³ (.006 ppm) over the range 60 to 300 µg/m³ (.03 to

.16 ppm). The method has an average bias of -3 percent over the range of 50 to 300 $\mu g/m^3$ (.03 to .16 ppm) (47).

NO_2 BY Chemiluminescence

The chemiluminescence procedure for measuring NO_2 uses the principle of gas phase reaction of NO and ozone to form NO_2 and light. Detection of NOx (NO + NO_2) requires conversion of NO_2 to NO since the reaction is directly proportional to NO in the presence of excess ozone. NO_2 concentrations are determined by the difference of NO and NOx. Typically, NO_2-to-NO converters are capable of quantitative conversion for long periods before needing maintenance (48).

This is an EPA Federal reference method (20). This principle has the application in ambient monitoring and automated monitoring networks in the range of 9 to 1,880 $\mu g/m^3$ (0.005 to 1 ppm) with linear response over these concentrations. Chemiluminescence instruments sample continuously and have a rapid response (less than 2 sec).

Gas phase titration is the recommended procedure in the concentration range of 0 to 1,880 $\mu g/m^3$ (0 to 1 ppm), and the calibration should be done monthly. Typically, converter (NO_2 to NO) efficiency is checked at this time. Instrumentation may be calibrated with NO_2 either from GPT of NO with ozone or from an NO_2 permeation device.

Zero and span checks are required weekly to determine precision within current guidelines (49). The weekly span check should provide NO_2 concentrations between 150 and 188 $\mu g/m^3$ (0.08 and 0.1 ppm) with a control limit of ± 47 $\mu g/m^3$ (± 0.025 ppm).

Accuracy data are acquired with quarterly performance audits using different standards and equipment at five concentrations. Precision is typically 9 $\mu g/m^3$ (5 ppb) (50, 51), and comparison of NO_2 calibration data obtained using NO_2 permeation devices with proper control procedures should show agreement within ± 5 percent (53, 54). Accuracy can be affected by small interferences from NH_3 and other compounds that can be converted to NO or may decompose to NO in the sample converter. The NH_3 interference is eliminated by operating the converter at a temperature of less than 400°C (752°F).

CARBON MONOXIDE, METHANE, AND NONMETHANE HYDROCARBONS BY FLAME IONIZATION DETECTION

Measured volumes of ambient air are delivered 4 to 12 times per hour to a gas chromatographic column where hydrocarbons (HC), CO_2 and water are separated from methane and CO. Methane (CH_4) is transferred and measured by a hydrogen flame ionization detector (FID). The CO is eluted to a catalytic reduction tube and reduced to CH_4 before passing through the FID. HC are also transferred quantitatively to the FID, and nonmethane hydrocarbons (NMHC) are determined by subtracting the methane from the total hydrocarbons (THC) value. This is the EPA reference method (54).

The method is applicable to the semicontinuous measurement of THC, CH_4, and CO in ambient atmospheres over the range 0.033 to 1.31 mg/m^3 (0.05 to 2.0 ppm) for THC and for CH_4 and 0.033 to 0.55 mg/m^3 (0.05 to 0.84 ppm) for CO (55).

Calibration gases of 5, 15, 40, and 80 percent of full-scale concentration range are used to determine linearity of the FID response to each component. The calibration gases consist of two component mixtures of CH_4 and CO and are used for all three components being analyzed, since each constituent is determined as CH_4.

Precision of repeated measurements of calibration gases is ± 0.5 percent of full-scale response at higher concentrations. At lower concentrations, precision of repeated measurement of calibration gases are ± 2 percent of full scale. Ambient air for NMHC measurements, however, can vary 0.322 ppm on the average, and the standard deviation can range from 0.217 to 0.454 ppm (56). Performance audits using standard materials supplied by EPA have demonstrated that CO measurements by FID over a range of 3.4 to 40.6 ppm produced an average difference of 2.3 percent (11).

HYDROGEN SULFIDE, MERCAPTANS, AND ORGANIC SULFIDES BY FLAME PHOTOMETRIC DETECTION

A gas-chromatographic separation of substances is used in conjunction with sulfur-specific detection by the flame photometric detector. The detector measures sulfur-containing gases at the 399 ± 5 nm emission line of sulfur in a hydrogen-rich flame, with a specificity ratio of sulfur to nonsulfur compounds of between 10,000 and 30,000 (57).

Sulfur-containing gases are sampled at -80°C (-112°F) by passing a known volume of air through a glass U-tube trap containing Porasil-D. H_2S, COS, SO_2, CH_3SH, CS_2, and $(CH_3)_2S$ in the range of 0.001 to 1.0 ppm are desorbed from glass-valved U-tubes at 40 to 100°C (104 to 212°F). The desorbed sample is injected onto a polyphenyl ether/phosphoric acid column at 40°C (104°F), and the eluted components are detected by the flame photometric detector. Other gas chromatography column materials have been found satisfactory, graphite, conditioned silica gel, and treated porous polymers, for example (57).

Typical 1-ml (.06 in.^{3}) volume samples may be stored no longer than 2 days because of sample reactivity. Very low levels (0.1 ppt H_2S) have been sampled and transferred to Teflon-coated sample loops at reduced pressure for analysis. Sampling was done on gold-coated sand.

A dynamic calibration system utilizing SO_2 permeating tubes with rates of 0.003 to 0.1 μg/min (4.62x10^{-8} to 1.54x10^{-6} grains/min) is required to prepare known atmospheres within the range of 5 to 1,000 ppb (58, 59, 60).

Precision within the range of 5 to 1,000 ppb should not be less than ± 1 percent of full scale. Reproducibility of thioacetamide standards analyses has been found to be ± 4.9 percent. Relative standard deviation of similar procedures is reported at 2.8 percent for less than 0.1 ng (1.54x10^{-9} grains) of sulfur (61). The limit of detection for H_2S has been determined at 0.01 ng (1.54x10^{-10} grains).

LEAD USING ATOMIC ABSORPTION SPECTROSCOPY

Suspended particulates in ambient air are collected on a glass-fiber filter for 24 hours using a high-volume sampler. Lead is extracted from filter strips using nitric acid and hydrochloric acid as an extracting solution and then sonifying for 30 minutes. The concentration of lead in the resulting solution is determined quantitatively using flame AA spectrophotometry (62). This method has now been designated as the Federal reference method (63).

Ambient air volumes of 2,400 m^3 (84,756 ft^3) are typical with a linear range of analysis of 15 µg/ml (.12 grains/ft^3). The method can be used for sample extracts containing between 0.03 and 7.5 µg/m^3 ($1.31x10^{-8}$ to $3.28x10^{-5}$ grains/ft^3) of inorganic lead. More concentrated solutions can be diluted, extending the upper limit of the range.

The sensitivity of flame AA for lead depends on many parameters, such as the instrument, light source, and wavelength used. The sensitivity when monitoring the absorption at 283.3 nm should be about 0.009 absorbance units per µg/ml ($7.51x10^{-8}$ lbs/gal) lead. The lower detectable limit of this method has been established at 0.03 µg/m^3 ($1.31x10^{-8}$ grains/ft^3) with 1 percent change in absorption at the 217 nm lead absorption line. The average coefficient of variation or relative standard deviation for 20 different levels of lead analyzed by this method is 1.0 percent. This gives an average relative standard deviation of 3.7 percent over the range of 80 to 125 µg/m^3 (64).

MERCURY METHODS

Atomic Absorption Spectroscopy

Ambient air is drawn through silver wool in glass tubing where elemental mercury is collected and later desorbed at high temperature for transfer to AA analysis (65). This sampling procedure has application for atmospheres with concentrations of 0.02 to 10 µg/m^3 ($8.74x10^{-9}$ to $4.37x10^{-6}$ grains/ft^3) at collection flow rates of 100 to 200 cm^3/min (6.1 to 12.2 $in.^3$) over a 24-hour period.

Five concentrations (multipoint) of mercury in air are analyzed weekly in the same way as samples. Recovery of mercury from the sample collection train has been 98 percent efficient over the range of 0.006 to 0.6 µg ± 4 percent ($9.24x10^{-8}$ to $9.24x10^{-6}$ grains) (66).

Cold Vapor Technique (Promising New Method)

Mercury in ambient air is determined by use of the cold vapor technique and flameless AA spectrometry. The mercury is collected by amalgamation with gold or silver. Then mercury vapor is released thermally and analyzed by AA spectroscopy. Ambient mercury levels from 15 ng/m^3 to 10 µg/m^3 ($6.56x10^{-9}$ to $4.37x10^{-6}$ grains/ft^3) can be measured. A detection limit of 0.3 ng ($4.62x10^{-9}$ grains) has been achieved. Calibration curves from 0.5 to 594 ng ($7.7x10^{-9}$ to $9.14x10^{-6}$ grains) Hg are reproducible to within 11 percent at 0.5 ng and to 3 percent relative standard deviation above 6 ng ($924x10^{-8}$ grains).

ARSENIC USING A HIGH-VOLUME SAMPLER

Air is sampled by high-volume sampler using glass fiber filters for 24 hours to collect particles. Arsenic and the more natural aerosol arsenic acid are extracted from filter strips using 0.5 percent sodium hydroxide (NaOH) as an extracting solution. The concentration of arsenic in the resulting solutions is determined using graphite-furnace AA spectrophotometry. This method can be used for sample extracts containing between 0 and 3 μg/ml (0 - 2.50×10^{-5} lbs/gal) arsenic. This corresponds to a 10 m^3 (353 ft^3) sample of ambient air with arsenic in the 0.1 to 1.0 μg/m^3 (4.37×10^{-8} to $4.37\times10^{-}$)concentration range. More concentrated solutions can be diluted and the upper limit of the range thereby extended.

The sensitivity of graphite-furnace AA for arsenic depends on the instrument, gas flow, and volume of sample used. Therefore it is not possible to quote a single value for the combined sampling and analytical procedure (67). The lower detectable limit of the method has not been established. Preliminary work has indicated that the average coefficient of variation when using this method is 4.0 percent.

METHODS FOR PARTICULATES

Stacked Membrane Filters (Promising New Method)

Ambient air is sampled, and particles in the air stream are physically separated into two size fractions by two filters with different pore sizes, 12 μm and 0.2 μm (4.72×10^{-4} and 7.87×10^{-6} in.); the filters are stacked in series (68, 69). Typical mass loadings on the two filters suitable for subsequent analyses are 25 and 16 μg (9.84×10^{-4} + 6.30×10^{-4}) for the large and small size fractions respectively.

These procedures have application where concentrations of the ambient atmospheric constituents are of the order of ng/m^3. Sampling flow rate is adjusted according to the face velocity required to meet calculated efficiency of collection on membrane filters (70).

Filter samples are transported to a laboratory for analysis of large- and small-size (relative) fractions by means of particle-induced x-ray emission (PIXE), which is a nondestructive analysis of elements with atomic numbers greater than or equal to sodium (71). Fluorescence or instrumental neutron activation analysis procedures may also be performed (72, 73). Subsequent analysis through extraction with ion chromatography and spectrophotometry is also feasible depending on minimum detectable concentration (74).

Precision and accuracy data are not complete for this procedure. Independent analysis by gravimetric and nondestructive procedures shows agreement within ± 5 percent. Monodispersive aerosol generation is used to test overall system sampling efficiency and accuracy.

Dichotomous Sampler (Promising New Method)

Ambient air is sampled, and particles in the air stream are physically separated according to size by inertial impaction and collected by filtration. Filter samples are transported to a laboratory where analyses of the size-fractionated particulate matter may be carried out through a variety of analytical procedures. Mass loading on the filters is sufficient for energy-dispersive x-ray fluorescence (EDXRF) spectroscopy, ion chromatography, and spectrophotometric analysis (74, 75). Nondestructive EDXRF analysis may be followed by sonification extraction and transfer with subsequent analysis (76). Hydrogen ion, sulfate ion by thorin spectrophotometry, ion exchange chromatography and ammonium analyses may be performed (74).

Ambient air is sampled for a period of time determined by the final analytical procedure to be performed on collected fractions. Typical sampling rates are adjusted from 14 to 50 l/min (3.7 to 13.2 gal/min). Pneumatic flow-rate control is used to reduce uncertainty in total air sample volume for filter sets corresponding to large and small particle-fraction concentration.

Calibration of each extraction and analysis has been performed according to Stevens, et al (74). Transfer of extraction solutions with analysis has shown greater than 95 percent efficiency with 2 percent or better standard deviation for size fractions containing hydrogen ions and sulfate. Ion-exchange chromatographic analysis in the $1x10^{-4}$ to $1x10^{-5}$ molar range for sulfate and nitrate ions has a standard deviation of 1 to 1.6 percent.

Comparisons of data for various applications of this sampling and analysis procedure for particulate show good agreement (76). However, accuracy statements on standards traceable to NBS are not available.

SULFATES USING THE METHYLTHYMOL BLUE METHOD

Ambient sulfates are collected by drawing air through a glass/fiber filter on a high-volume sampler (77). The filters are placed in H_2O, and the extract is analyzed for sulfates by the methylthymol blue (MTB) method using a single channel Technicon Autoanalyzer II system equipped with a linearizer (78). The MTB method is based on the spectral difference that exists in basic solutions (pH 12.5 to 13.0), between the barium ion (Ba^{++}) complex of MTB and the free MTB. At this pH the barium complex is blue and the free ligand is brownish-red (absorbs light at 460 nm). Thus the solution containing both the free ligand and the complex appears gray. The amount of free ligand, monitored colorimetrically at 460 nm, is a measure of the amount of sulfate in the sample because the reaction of sulfate with $MTB\text{-}Ba^{++}$ results in an equivalent amount of free ligand.

The method is applicable to the collection of 24-hour samples in the field and subsequent analysis in the laboratory. The range of the analysis is 3.0 to 95.0 µg $SO_4^{=}$/ml ($2.50x10^{-5}$ to $7.93x10^{-4}$ lbs/gal). With a 50-ml (1.69 oz) extract from 1/12 of the exposed high-volume filter collected at a sampling rate of 1.7 m^3/min (60 cfm) for 24 hours, the range of the method is 0.6 to 19 µg/m^3 ($2.62x^{-7}$ to $8.30x10^{-6}$ grains/ft^3. The lower range may be extended up to 10-fold by increasing the portion of the filter extracted. Concentrations greater than 95 µg/ml ($7.93x10^{-4}$ grains/ft^3) are determined after dilution with distilled water.

Cations such as calcium, aluminum, and iron interfere by complexing the MTB. These ions are removed by passage through a cation-exchange column. Cations such as Ca^{+2} or Pb^{+2} form insoluble sulfates, which in sufficient concentrations cause a negative interference.

Quality assurance procedures are set forth in Guidelines for Development of a Quality Assurance Program Analysis calibration is done at the beginning of each day's run and checked at the end. Calibration standards are run every tenth sample and quality assurance audit samples are also analyzed blind throughout the day's run. Relative standard deviation of quality assurance audit samples analyzed over several months ranged from 2 to 4 percent. Percent recoveries for quality assurance audit samples analyzed blind ranged from 91 to 99 percent.

NITRATES USING COPPERIZED CADMIUM REDUCTION

Ambient nitrates are collected by drawing air through a glass fiber filter on a high-volume sampler (77). Nitrates are extracted from the exposed high-volume filters using water, and analyzed by reduction of the nitrate to nitrite using a copperized cadmium reductor column. The nitrite is reacted with sulfanilamide in acidic solution to form a diazo compound. This compound then couples with N-1-naphthylenediamine dihydrochloride to form a reddish purple azo dye, which is determined colorimetrically at 520 nm using a Technicon Autoanalyzer II (79).

The range of the analysis is 0.1 to 30.0 μg NO_3^-/ml (8.34×10^{-7} - 2.50×10^{-4} lbs/gal). With a 50-ml (1.69 oz) extract from 1/12 of the exposed high-volume filter collected at a sampling rate of 1.7 m^3/minute (60 cfm) for 24 hours, the range of the method is 0.03 to 7.4 μg/m^3 (1.31×10^{-8} to 3.23×10^{-6} grains/ft^3. The lower range may be extended up to 10 fold by increasing the portion of filter extracted. Concentrations greater than 30 μg are determined after dilution with distilled water.

The sampling quality assurance program follows the criteria given in the EPA Guidelines (25). Analysis calibration is performed at the beginning and end of each day's run, and a calibration standard is analyzed every tenth sample. In addition, blind analyses of audit samples are performed. The relative standard deviation audit sample results over several months was in the range of 2 to 3 percent. Percent recoveries for quality assurance audit samples (analyzed blind) ranged from 94 to 103 percent. Metal ions may produce a positive error. For example, divalent mercury and divalent copper may form colored complex ions having absorption bands in the region of color measurement.

FLUORIDE ON HIGH-VOLUME FILTERS

Fluorides are collected on glass fiber high-volume filters and extracted using water. Fluoride concentrations are determined using a fluoride selective electrode in conjunction with a standard pH meter with an expanded millivolt scale or fluoride-specific ion meter. Electrode potentials are measured at 60-, 90-, and 120-second intervals. Values extrapolated over long times are calculated and compared with the calibration curve determined from standard fluoride solutions (80).

The detection limit is approximately 0.002 μg F^-/ml (1.67×10^{-8} lbs/gal). The upper range for this procedure is 0.1 μg F^-/ml (8.34×10^{-7} lbs/gal). Samples with fluoride concentration above this upper working limit can be analyzed using appropriate dilution techniques.

Samples should be analyzed immediately upon completion of the sampling period. If storage is required, the sample should be stored in a dark cool place.

Standard solutions of fluoride in concentrations of 0.1, 0.08, 0.04, and 0.01 µg/ml (8.34×10^{-7}, 6.68×10^{-7}, 8.34×10^{-8} lbs/gal), are analyzed in random order to determine the calibration curve for the method. The 60-, 90-, and 120-second potential responses are recorded. These results are fit by least squares to a linear relation as follows: $\Sigma obs = \Sigma o + F/\text{time immersed}$, where Σo and F are the constants to be determined.

Water soluble samples are measured. The 60-, 90-, and 120-second intervals are recorded, and an Σo for the sample is calculated as described above. The fluoride concentration of an unknown is determined via direct comparison of the sample Σo value to the calibration curve. The precision of analysis of quality assurance audit samples is in the general range of 5 to 10 percent relative standard deviation. The accuracy of the analysis of quality assurance samples is within ± 5 to 10 percent of the audit sample prepared from National Bureau of Standards synthetic rainwater.

Extreme pH ranges interfere in the measurement of F^- concentration; pH can be controlled in the 5.0 to 9.0 pH range by use of an appropriate buffer. Polyvalent cations complex the F^-. Use of a buffered chelating agent removes these cations. Fluoride measurement with a millivolt meter is pH- and temperature dependent. Analyses should be performed at 25°C (77°F).

AMMONIA METHODS

Colorimetric Analysis

Sampling is accomplished by pulling a known volume of air through a fritted bubbler (81). The sampling train should be protected by the placement of a glass filter in an ammonium-free filter holder before the bubbler. Atmospheric ammonia is collected by drawing the air through a dilute sulfuric acid solution. Ammonium sulfate is formed and then reacted with phenol and alkaline sodium hypochlorite to form the blue dye, indophenol. Sodium nitroprusside is used as a catalyst to speed up the reaction. After reaction is complete, the solution can be analyzed spectrophotometrically (82). The mechanism of this reaction has been proposed by Rommers and Vissor (83).

The range and sensitivity of the method is reported as 17 to 700 µg/m^3 (0.025-1 ppm), with a sampling rate of 1 to 2 l/min (.26 to .52 gal/min) over a sampling time of one hour (84). The detection limit is 0.02 µg/m^3 (8.74×10^{-9} grains/ft^3) (84).

Ferrous, chromous, and manganous ions cause positive interference if they are present in milligram amounts. Copper ions inhibit color development. Addition of ethylene-diamine tetraacetic acid (EDTA) removes these interferences (82). Nitrite and sulfite interfere if they are present in excessive quantities (100 times that of the NH_3). Formaldehyde causes a negative interference (84). Particulate matter and ammonium compounds that may become entrained in the collecting solution are removed by the glass prefilters.

Multipoint calibration curves of μg NH_3 versus absorbance are required in the analysis procedure. These curves should be prepared in a concentration range that brackets expected sample solution concentrations. The precision of this test when analysis is performed manually near the lower end of the range shows a variation of 30 percent (84).

Absorption and Chemiluminescent Principle (Promising New Method)

Ammonia is absorbed and preconcentrated from ambient air being passed through a suitable teflon-bead substrate. The ammonia is desorbed from the substrate in the laboratory and quantitatively oxidized to NO_2 for analysis by chemiluminescence. The method shows promise for application in remote areas where ambient concentrations are low. Sample preconcentration is necessary to produce meaningful response at these concentrations.

BENZO(α)PYRENE USING FLUOROMETRIC ANALYSIS

Ambient air is sampled by air passing through fiber glass filters and silver membrane filters in series. Sample volume is determined by concentrations expected in the atmosphere being examined. Flow rate control is recommended to reduce sampling variability (85).

Blank filters and samples are shipped to the laboratory in light-proof containers for analysis. The filters are removed from the filter holder and placed in test tubes under benzene. The solvent extraction of organic sample is aided by ultrasonic action.

The benzo(α)pyrene (BaP) fractions from the thin layer chromatography separations are extracted, evaporated, and dissolved in sulfuric acid for quantitative fluorometric measurement (85). Laboratory operations up to a point of fluorescence measurement are conducted under yellow light to avoid inadvertent photooxidation of any BaP in sample solutions.

The fluorometric final analytical step of the procedure is linear over the range of 10 to 400 ng (1.54×10^{-7} to 6.17×10^{-6} grains) , and sample aliquot size from the benzene extraction must be adjusted so that sample concentration falls in this analytical range. Typically, ambient air containing 0.02 to 0.8 $\mu g/m^3$ (8.74×10^{-9} to 3.50×10^{-7} grains/ft^3) would correspond to this range.

Pure internal standards are used to develop calibration factors in the spectrophotofluorometer. Samples and standards are analyzed together. Fluorescence intensity of the filters is calculated and corrected for BaP content of filter blanks. The coefficient of variation of the analytical procedure is estimated to be ± 0.07 in the range of 10 to 400 ng (1.54×10^{-7} to 6.17×10^{-6} grains) of BaP. Accuracy is affected by sample handling, transfer procedures, and thin-layer chromatographic extraction process and can be minimized if a controlled BaP standard is carried through the whole analysis process.

C_1 THROUGH C_5 HYDROCARBONS USING GAS CHROMATOGRAPHY

Ambient air samples are collected through grab sampling techniques using plastic bags with air valves. The plastic bags are flushed three times with ambient air and then filled for transport to the GC for analysis. Portions of the ambient air in the bag are analyzed for C_1 through C_5 hydrocarbons by gas chromatography (86). Analysis is performed on a single column at 0°C (32°F) with separated components being detected by FID.

The method has applications in atmospheres containing 0.01 ppm. The lower limit for C_3 through C_5 hydrocarbons can be extended by concentrating 100 ml (.026 gal) aliquots of sample in a freeze trap. This limit is 0.1 ppbv.

Preliminary screening of a representative sample provides a qualitative analysis for each hydrocarbon to be measured. Calibration standards are then prepared by dilution and transferred to a plastic bag. Retention times are determined for each hydrocarbon and the standards are used for comparison to samples. A response factor and FID response is used in calculations to calibrate ambient concentration of C_1 through C_5 hydrocarbons.

ORGANICS BY ABSORPTION, PURGE, AND TRAP GAS CHROMATOGRAPHY

Ambient organic concentrations are determined on a semiquantitative basis by sampling through specially designed cartridges mounted in place of the filter on a high-volume air sampler. Absorbed organic material is quantitatively desorbed from the cartridge with separation and identification by GC/MS (87).

The technique has application in ambient atmospheres with concentrations of organics ranging from baseline levels (low concentrations) to relatively high concentrations when sampling for specific time periods at 100 to 250 l/min (26.4 to 66.0 gal/min) (88). Detection limits are typically 0.1 ng/m^3 (4.37×10^{-11} grains/ft^3) (89). Sample contamination and substrate interferences lead to error if the procedures are not carefully specified.

Samples must be held at subzero temperatures in darkness to avoid absorptive losses of organics on substrate to the sample container walls (90). Efficiency of recovery from sampling containers depends on both vapor pressure and water solubility of organic materials sampled.

Calibration of organic sampling and analysis procedures are performed by quantifying error in all phases of the process. The procedure consists of efficiency tests in collection, storage, separation, and concentration in the analytical phase of the process, and definite quantification in the screening process through use of standard materials. Uncertainty of the sampling extraction and analytic processes is about 40 ng of C_6 constituents for both the GC/MS analyses.

PAH USING UV SPECTROSCOPY

Sampling is conducted by passing air through either a membrane or glass fiber filters with subsequent gas chromatograph separation of extraction mixtures. Filter blanks and samples must be shipped to the laboratory in light-proof containers.

Polynuclear aromatic hydrocarbons (PAH's) are collected from GC eluate and analyzed by UV spectroscopy (85).

The method has a range of concentration from 2 to 1000 $\mu g/m^3$ (8.74×10^{-7} to 4.37×10^{-4} grains/ft^3), with sample volumes as low as 0.5 m^3 (17.65 gt^3). Detection limits lie in the range of 0.2 to 2.7 µg/sample (3.09×10^{-6} to 1.12×10^{-4} grains) for individual compounds as collected on membrane filters. At about 2 ppm, sampling is performed with glass fiber filters in series with silver membranes. Ambient concentrations in most oil shale development areas will require sampling periods of 24 hours.

Retention times are determined with the GC using pure O-terephenyl and biphenyl internal standards and procedures (85). The UV spectrophotometer is calibrated by recording the reference absorption spectrum of internal standard solutions at four different concentrations. A calibration factor is developed for each sample compound and the internal standard by dividing concentration by absorbance.

Calculations to determine the weight of each PAH are started, using recovery factors of internal standards through the separation and eluate fraction collection procedure (91). The weight in micrograms of each compound is then calculated using the absorbance and UV calibration factor for the polynuclear compound.

No method for either precision or accuracy has yet been determined for collection of the sample, extraction, calibration, and final analysis. Duplicate analyses of the same organic fraction show a precision of ± 10 percent (91).

POLYCYCLIC ORGANIC MATTER

Filter samples of particulate polycyclic organic matter (POM) are extracted ultrasonically in CS_2 or benzene solvent and the solvent solution is analyzed by FID and GC. The method is not specific, and analysis is qualitative for classes of compounds as defined in the Federal Register (92).

Glass fiber filters in polystyrene or polycarbonate filter cassettes are used to sample air at 2 to 6 l/min (0.07 to 0.21 ft^3/min), depending on ambient concentrations for 8 hours or more (93). Exhaust flows should be isolated from the sampling area to prevent sampling carbon from the pump. Ambient concentrations of 0.05 to 10 mg/ml (4.17×10^{-7} to 8.34×10^{-5}) are measured in sampled air.

Anthracene, pyrene, chrysene, BaP, and 1,12 benzoperylene are dissolved in solvent to provide a representative calibration curve of 3- to 6-ring compound samples. Precision has been reported at ± 5 percent by within-laboratory single operation as seen in the ASTM Annual Book of Standards (93). Accuracy data are not yet available.

ASBESTOS AND ASBESTOS-LIKE FIBERS

Ambient air is drawn through a membrane filter, and the filter is analyzed optically (94, 95). The method is the method of test in the U.S. Public Health Service criteria document on occupational exposure to asbestos (96, 97) and is listed in the 1974 ASTM Annual Book of Standards (98). The method with suitable sampling periods has application in atmospheres containing concentrations of asbestos and asbestos-like fibers over the range of 1 to 20 fibers/cm^3 (.06 in.^{3}). Fibers longer than 5 μm (1.97x10^{-4} in.) are counted.

Sampling is done at 1.0 to 2.5 l/min (.26 to .66 g/m) for a time period sufficient for concentrations of sampled fibers longer than 5 μm to be analyzed. Particulate matter with a length-to-width ration of 3 to 1 or greater and a length greater than 5 μm can interfere if it has not been identified as asbestiform material.

Sampling flow rate is calibrated against traceable standards once each month. Phase contrast analysis of fibers is standardized using Porton reticule and stage micrometers for size comparison. Reproducible results depend on accurate screening of fibers greater than 5 μm and equal to or greater than 3:1 length-to-width ratio. The Bureau of Mines shows that asbestiform minerals have an aspect ratio between 10 to 1 and 20 to 1, and this will probably become a criterion in defining asbestos or asbestos-like fibers (99).

Precision of counting fibers on membrane filters has been estimated at 16.2 percent (100). The procedure has a standard deviation of 21.4 percent. For samples with a low concentration of fine fibers, the standard deviation is estimated at ± 45 percent at the 95 percent confidence interval. The National Institute of Occupational Safety and Health (101) has estimated standard deviation for counting at the 95 percent confidence interval at ± 30 percent. Geometric concentrations of asbestos can be used to determine accuracy by use of a factor developed by Thompson (102).

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Prepared by Jacobs Environmental,
a Division of Jacobs Engineering Group Inc.

APPENDIX C

ENVIRONMENTAL MONITORING ACTIVITIES - PAST, PRESENT, AND PROPOSED

TRACT C-a

Air Resources

Baseline Data Gathering Program--

The environmental baseline study was conducted in accordance with the stipulations of the Oil Shale Lease C-20046 issued to Gulf Oil Corp. and Standard Oil Co. (Indiana) in February 1974. The regional location of Tract C-a is illustrated in Figure C-1.

The Rio Blanco Oil Shale Project (RBOSP) baseline environmental studies were conducted between 1974 and 1976 by Gulf, Standard, and various subcontractors. The published documents that have been used in the preparation of this report are RBOSP Final Environmental Baseline Report for Tract C-a and Vicinity, May 1977, Volumes 1 and 2 (1), and RBOSP Environmental Baseline Data Accumulation Program C-a, Revised December 1975 (2).

Baseline air quality data were gathered at four monitoring sites around the Tract C-a area. The approximate locations of these sites are presented in Figure C-2.

Ambient air was measured for concentrations of THC, CH_4, SO_2, H_2S, NOx, NO, CO, O_3, and TSP; the latter were characterized for particulate size. The air quality parameters measured at each site during baseline are presented in Table C-1, together with the equipment used for instrumentation and measurement. High-volume filter material (TSP) was also analyzed for the following trace elements:

Uranium
Thorium
Bismuth
Lead
Thalium
Mercury
Gold
Platinum
Iridium
Osmium
Rhenium
Tungsten
Dysprosium
Terbium
Gadolinium
Europium
Samarium
Neodymium
Praseodymium
Cerium
Lanthanum
Barium
Cesium
Iodine
Rhodium
Ruthenium
Molybdenum
Niobium
Zirconium
Yttrium
Strontium
Rubidium
Bromine
Selenium
Arsenic
Germanium
Chromium
Vanadium
Titanium
Scandium
Calcium
Potassium
Chlorine
Sulfur
Phosphorus
Silicon
Aluminum
Magnesium

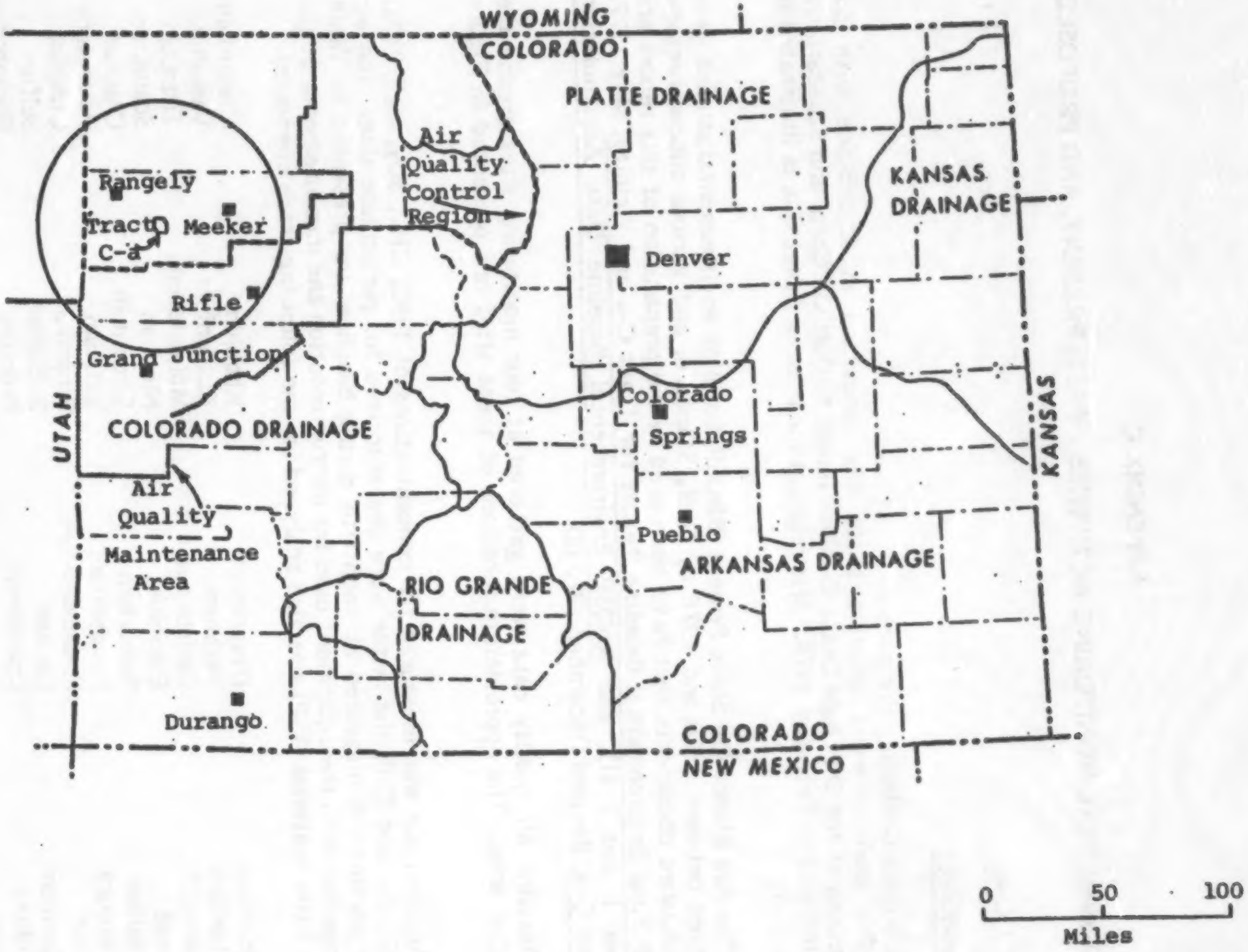
WYOMING
COLORADO
PLATTE DRAINAGE
KANSAS DRAINAGE
Air Quality Control Region
Rangely
Tract C-a
Meeker
Rifle
Denver
Grand Junction
Colorado Springs
UTAH
COLORADO DRAINAGE
KANSAS
Air Quality Maintenance Area
Pueblo
ARKANSAS DRAINAGE
RIO GRANDE DRAINAGE
Durango
COLORADO
NEW MEXICO
0
50
100
Miles

Figure C-1. Tract C-a, regional location map.

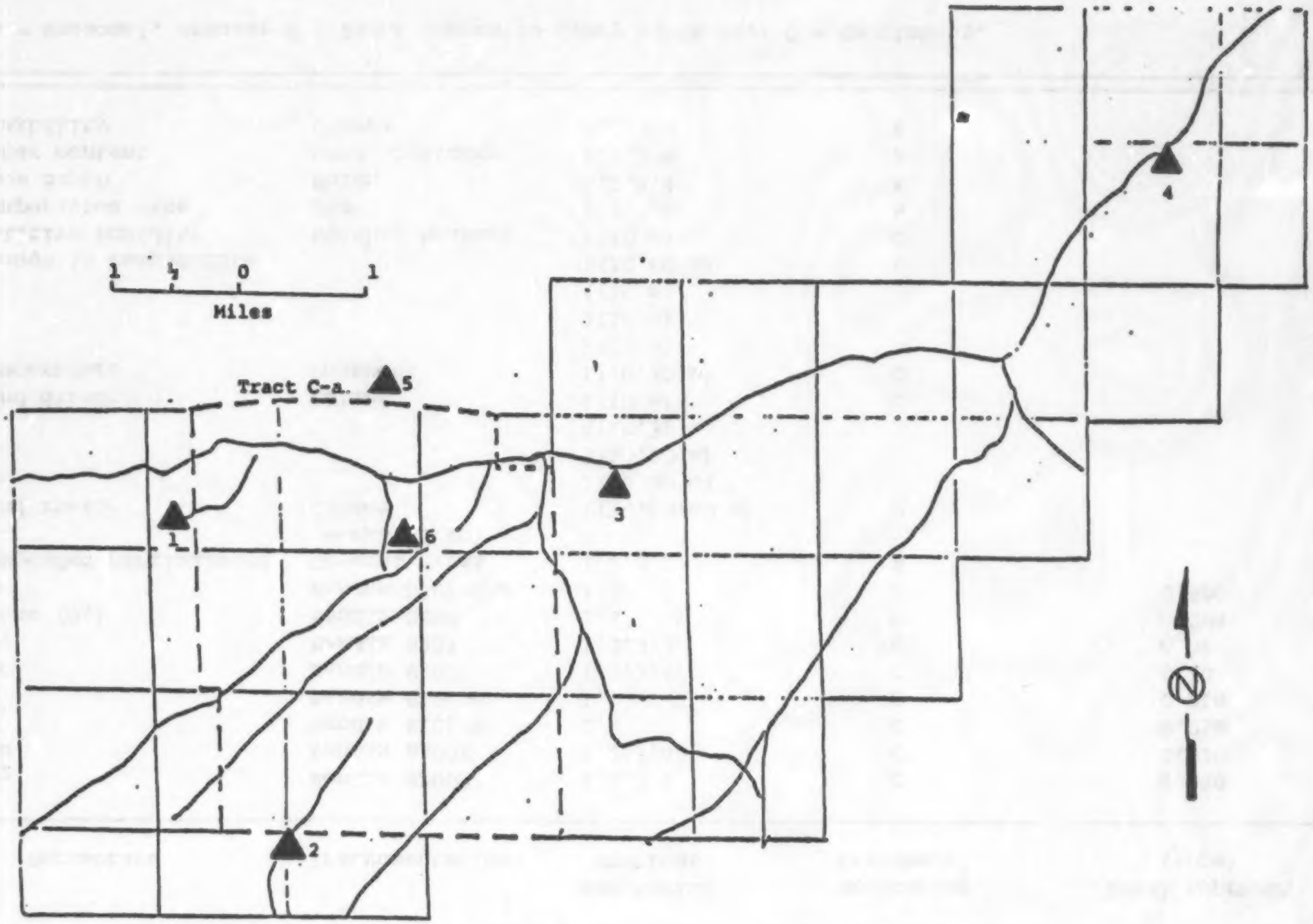
1
½
0
1
Miles
Tract C-a
5
1
6
3
2
4
N

Figure C-2. Location map for Tract C-a air quality and meteorology monitoring stations.

TABLE C-1. AIR QUALITY AND METEOROLOGICAL PARAMETERS, INSTRUMENTATION, SAMPLING FREQUENCY, AND SCHEDULES OF THE BASELINE AIR RESOURCES MONITORING PROGRAM FOR TRACT C-a

Parameters	Instrumentation	Monitoring stations	Monitoring frequency[a]	Total approach (±ppm)
SO_2	Bendix 8200X	1,2,3,4	C	0.020
H_2S	Bendix 8200X	1,2,3,4	C	0.020
NO_x	Bendix 8101-B	1,3	C	0.010
NO	Bendix 8101-B	1,3	C	0.010
THC	Bendix 8207	1,2,3,4	C	0.10
CH_4	Bendix 8207	1,2,3,4	C	0.02
Ozone (O_3)	Bendix 8002	1,3	C	0.004
CO	Bendix 8501-5CA	1,3	C	0.500
Suspended particulated	General Metal Works Hi Vol	1,2,3,4	B	
Wind speed	Climet	1(10,30,60 m) 2(10,30 m) 3(10,30 m) 4(10,30 m)	C	
Wind direction	Climet	1(10 m)	C	
Temperature	Rosemont	1(10,30 m) 2(10 m) 3(10 m) 4(10 m)	C	
Change in temperature		1(10,60 m)	C	
Relative humidity	Weather Measure	1(10 m)	C	
Evaporation rate	Pan	1,2,3,4	A	
Snow depth	Ruler	1,2,3,4	A	
Water content	Grad. cylinder	1,2,3,4	A	
Visibility	Camera	1,2,3,4	A	

[a] A = Seasonal, annual; B = 24-hr composite every sixth day; C = Continuous.

Tantalum
Hafnium
Lutecium
Ytterbium
Thulium
Erbium
Holmium
Lithium
Tellurium
Antimony
Tin
Indium
Cadmium
Silver
Palladium
Gallium
Zinc
Copper
Nickel
Cobalt
Iron
Manganese
Sodium
Fluorine
Oxygen
Nitrogen
Carbon
Boron
Beryllium

Climatological data were gathered from two sources during baseline data gathering. Data that were already established around the Tract C-a area and data created as part of the baseline data gathering program have been used to determine climatological characteristics of the immediate locality. Meteorological data were acquired at four locations around Tract C-a. These locations have been plotted and are illustrated in Figure C-2. The main meteorological tower is at Station 1 and is approximately 60 m (197 ft) high. The remainder of the towers are 10 m (33 ft) high. The parameters being measured on a routine basis at each site are presented in Table C-1. Seasonal and annual measurements include: evaporation rate, snow depth and water content, and visibility. To assure reliability of baseline meteorological data, a quality assurance program was established to meet requirements specified under 10 CFR 50, Appendix D.

Upper air meteorological measurements were made over four 15-day quarterly periods during 1974 and 1975. These periods were in the fall (October 1974), the winter (January-February 1975), the spring (April-May 1975), and the summer (July 1975). A summary of the sounding experiment is presented in Table C-2.

Ambient temperature soundings were made between 1,920 m (6,300 ft) and 3,962 m (13,000 ft) at 30.5 m (100 ft) increments. Wind speed and direction soundings were made from about 610 m to 3,962 m at 91.5 m (2,000 ft to 13,000 ft at 300 ft) increments. After the data were developed, an analysis of seasonal air mixing was performed.

Tracer studies for the purpose of testing atmospheric diffusion were conducted on 10 specific occasions, varying in length from 4 to 24 hr, for a total test time of 87 hr. In addition, the Rio Blanco Oil Shale Project (RBOSP) ran an air quality dispersion model tailored to the Tract C-a site.

Interim Monitoring Program—

In September 1976, RBOSP was granted a suspension of operations for 1 year. During that 1 year, an interim monitoring program was initiated to maintain a continuous data base on critical parameters that had been studied in the baseline program. This section will summarize the proceedings of that study as reported in References 3, 4, and 5. The primary contractor for these studies was the NUS Corp.

During the interim study monitoring programs, one air quality station (Site 1) was left operational and was equipped for the continual measurement of SO_2, H_2S, NO, NOx, CO, O_3, CH_4, and THC. The location of this monitoring site is shown on Figure C-2. The instruments used represented the state-of-the-art in automatic instrument pollutant monitoring. In addition, particulates were sampled by two high-volume samplers, one at ground level 1.5 m (5 ft) and the other at 7 m (23 ft)

TABLE C-2. ATMOSPHERIC DIFFUSION SOUNDING TEST RESULTS OF BASELINE AIR RESOURCES MONITORING PROGRAM FOR TRACT C-a

	Average mixing layer height for a 300-ft stack[a]								
	Sounding 1		Sounding 2		Sounding 3		Sounding 4		
Time of measurement period	Height (ft)	Freq. of occurrence	Height (ft)	Freq. of occurrence	Height (ft)	Freq. of occurrence	Height (ft)	Freq. of occurrence	Mean time to inversion breakup (MST)
Fall	642	0.67	400[b]	0.09	---	---	---	---	7:50
Winter	2,371	0.47	950	0.27	2,900	0.13	2,788	0.27	11:45
Spring	3,067	0.20	---	---	---	---	---	---	6:50
Summer	588	0.20	---	---	---	---	---	---	7:00
Annual	1,477	---	950	---	---	---	2,788	---	---

[a] Data only considered for inversions above level of tract (7,200 ft).

[b] Based on fewer than three occurrences.

aboveground. Wet chemical determinations were made for SO_2, H_2S, NO, NOx, and O_3 for purposes of comparison with automatic ambient data.

During this study a complete and accurate set of program documentation was generated. Several major pieces of equipment were reconditioned. The magnetic tape deck and station teletype were reconditioned, the standby-emergency power supplies were serviced to reduce station noise levels and repair electronic component damage apparently caused by lightning. Frequent, short-term interruptions in commercial primary power continued to be a problem. The 360° wind direction sensors were replaced with NOIC certified 540° units to eliminate problems with the back-up strip chart recordings of wind direction.

The monitoring site was visited on an average of every other day by the site technician. A station checklist was completed for each week of operation. A zero and span test of the gas monitoring instruments was conducted weekly. Control charts were made to evaluate instrument stability and performance. During the interim monitoring period the site was subjected to voluntary EPA audits under the Western Energy Quality Assurance Program. The performance of the NUS Rockville air quality laboratory was also subjected to audit through a collaborative interlaboratory testing program.

The 60 m (197 ft) tower at Site 1 was also used to monitor meteorology during the interim program. The parameters measured on the tower included temperature, wind speed and direction (10 m, 30 m, and 60 m or 33 ft, 99 ft, and 197 ft), relative humidity, wind sigma, differential temperature (10 m, 60 m or 33 ft, 197 ft), and solar radiation.

The precipitation monitoring program was the same as the one employed during baseline monitoring except for the precipitation chemistry monitoring program which was added during interim monitoring. Precipitation chemistry was measured on samples of rain and snow collected in specially cleaned containers. Once the sample was taken it was transferred to nalgene containers and analyzed for: arsenic, cadmium, chromium, copper, lead, molybdenum, mercury, selenium, bromide, calcium, chloride, magnesium, potassium, sodium, iron, pH, fluoride, sulfate, total dissolved solids, bicarbonate, carbonate, total nitrogen, and silicon dioxide.

Modular Development Phase Monitoring Program--

On January 1, 1978 the Rio Blanco Oil Shale Project (RBOSP) was renamed the Rio Blanco Oil Shale Company (RBOSC). Since this change took place during the modular development phase, all references to the Tract C-a development will be RBOSC.

Environmental studies that are presently taking place are part of a 4-year and 4-month period program entitled the RBOSC modular development phase monitoring program (MDPMP). The program is set up to operate in accordance with the guidelines set up in the RBOSP detailed development plan, May 1977. The program schedule is as follows:

Year 1	September - December 1977 (4 months)
Year 2	January - December 1978 (12 months)

Based on results of the baseline, interim and modular development phase monitoring programs (years 1 and 2), a revised program has been developed to address adequately the period during which RBOSC will be constructing modular development phase retorts and associated support facilities for the ignition and burn of five modular development phase retorts. The time period to be covered includes the following:

Year 3	January - December 1979
Year 4	January - December 1980
Year 5	January - December 1981

Since only hydrocarbons and ozone were found in significant quantities during baseline studies, special attention is being paid to the monitoring of these pollutants in the second half of the modular development phase air resources monitoring program.

The modular development phase monitoring program has been set up as a dynamic program. This means that it is subject to alteration at any time upon conference and agreement with the Area Oil Shale Supervisor. The outline of this program is not to be taken as program guidelines. The primary contractor for this program is the NUS Corp. The documents that have been used in preparation of this section are References 6-10.

The monitoring of gaseous pollutants in the Tract C-a area is presently being carried out by automatic instrumentation at monitoring Sites 1 and 3 during the modular development phase monitoring program. Monitoring at Site 5 will follow at a later date. The locations of these monitoring stations are presented in Figure C-2. A description of the parameters being measured, the date of program institution, and the sampling frequency for each site is shown in Table C-3.

The system at Site 1 is continuous and one that automatically scans all parameters at each site approximately 3.6 times/min and computes a running 15-min, 1-hr average. The data are recorded on magnetic tape. When the instruments are serviced and maintained on a regular basis, data recovery should be close to 90 percent annually. The detection techniques in use in the tract instrumentation meet the requirements of reference methods specifications. Calibration of the air quality instrumentation is performed at least once each season (90-day period). Once the data is placed on strip charts and magnetic tapes, it is transferred to the NUS data reduction group on a biweekly basis. Finally, the air quality data will be examined for frequency of occurrence and interpreted graphically.

Particulates are being monitored at three (1, 2, and 3) air quality monitoring sites on Tract C-a. The locations of these particulate monitoring sites are shown in Figure C-2.

Particulate samples are being taken at all points by high volume General Metal Works particulate samplers, which are situated approximately 6 m (20 ft) above ground level. One 24-hr volume sample is taken by each of the five samplers every third day. The schedules for each sampling site are summarized in Table C-3. The

TABLE C-3. AIR QUALITY MONITORING SCHEDULE FOR THE MODULAR DEVELOPMENT PHASE MONITORING PROGRAM AT TRACT C-a

Parameter	Sampling location	Starting date	Sampling frequency
Sulfur dioxide	Site 1	Sept. 1977	Continuous
	Site 3	Jan. 1978	Continuous
	Sites 2,5[a]	Sept. 1979	Continuous
Hydrogen sulfide	Site 1	Sept. 1977	Continuous
	Site 3	Jan. 1978	Continuous
	Site 2[a]	Sept. 1979	Continuous
Nitric oxide	Site 1	Sept. 1977	Continuous
	Site 3	Sept. 1979	Continuous
Nitrogen oxides	Site 1	Sept. 1977	Continuous
	Site 3	Sept. 1979	Continuous
Carbon Monoxide	Site 1	Sept. 1977	Continuous
	Site 3	Sept. 1979	Continuous
Ozone	Site 1	Sept. 1977	Continuous
	Site 3	Nov. 1979	Continuous
Particulates	Sites 1,2,3	Dec. 1977	Continuous
	Site 6[b]	Nov. 1977	Every 3rd day

[a] Proposed for modular development phase operation.

[b] Discontinued by permission.

high-volume sampler flow rates are calibrated quarterly with a standard orifice plate.

Meteorological parameters are being measured at Sites 1, 2, and 3. The locations of these three sites are shown on Figure C-2.

The parameters to be measured are wind direction, wind speed, wind sigma, ambient temperature, temperature, precipitation, solar radiation, and dewpoint. The frequency with which these parameters will be measured and the date of program initiation for each sampling site is summarized in Table C-4.

The data acquisition system scans each parameter approximately 3.6 times every minute and computes a 15-min average, from which a 1-hr average is derived during data reduction. All instrumentation is maintained and serviced on a regular basis to assure accuracy. The data are recorded on magnetic tape that is returned to NUS for computer listing, scaling, and strip-chart reduction.

The Clean Air Act as amended in 1977 declares that prevention of visibility impairment from manmade air pollution is a national goal in mandatory Federal PSD Class I air quality areas.

A visibility program will be made part of modular development phase monitoring. Measurements will be taken over both long and very short pathlengths, utilizing, most likely, a telephotometer.

Proposed Commercial Development Phase Monitoring Program--

Construction on commercial operation facilities is intended to begin in June 1982, and commercial operation is intended to ensue in February 1987. The Commercial development phase monitoring program will be active during this time period, from June 1982 until completion of the project.

Details of the proposed commercial phase monitoring program were provided in the RBOSP Revised Detailed Development Plan: Tract C-a, May 1972, Vol. 3 (11). The monitoring program as proposed in the revised DDP and as summarized here is very tentative due to changes in the engineering plan, improvements in monitoring technology, and changes in applicable regulations.

Air quality parameters will be monitored at four locations around the Tract C-a area during commercial operation. Monitoring Site 1 will be situated in a position that represents the area of maximum impact. Site 2 will be maintained in an area representing the upwind side of the tract, and Site 3 will be at the downwind tract periphery. The locations of these sites is presented in Figure C-2.

The Tract C-a long-term monitoring program will monitor atmospheric suspended particulates, sulfur dioxide, nitrogen dioxide, oxidants (as ozone), hydrogen sulfide, methane, nonmethane hydrocarbons, carbon monoxide, and visibility. Along with the monitoring done at established sampling Sites 1, 2, and 3, one additional high-volume sampler may be operated in an area of high vehicular traffic at 3 m (10 ft) aboveground. The monitoring site is to be equipped with a sulfur dioxide detector, a high-volume sampler, and a nonmethane hydrocarbon detector. These three pollutants are the most likely to be emitted, and hence they

TABLE C-4. METEOROLOGICAL PARAMETER MONITORING SCHEDULE FOR THE MODULAR DEVELOPMENT PHASE MONITORING PROGRAM AT TRACT C-a

Parameter	Sampling location	Starting date	Sampling frequency
Wind direction (10m)	Sites 1,2	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Wind direction (60m)	Site 1	Sept. 1, 1977	Continuously
Wind speed (10m)	Sites 1,2	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Wind speed (60m)	Site 1	Sept. 1, 1977	Continuously
Wind sigma (10m)	Site 1	Sept. 1, 1977	Continuously
Ambient temperature (10m)	Sites 1,2	Sept. 1, 1977	Continuously
	Site 3	June 1, 1979	Continuously
Temperature (10 & 60m)	Site 1	Sept. 1, 1977	Continuously
Precipitation (tipping) bucket & recording guage	Site 1	Sept. 1, 1977	Continuously
Solar radiation	Site 1	Sept. 1, 1977	Continuously
Dewpoint	Site 1	July 29, 1979	Continuously

are considered good overall indicators of the diffusion of pollutants from the operations.

Site 1 will be equipped with a system capable of collecting continuous data scans and recording data as hourly averages for each gaseous pollutant. Hourly averages may be computed for all stations. Data will be analyzed quarterly (end of each season) and summarized annually. Suspended particulates would be sampled every sixth day. Calibrations will be performed quarterly, or whenever is necessary. The calibration report will be a part of the quarterly data analysis report.

The specific requirements of a source emission monitoring program have not yet been defined. Source monitoring and stack sampling that will be necessary for permit compliance will be included in the final design and all necessary access facilities will be installed. During the modular development phase, a trace element analysis will be made of the thermal oxidizer flue gas.

Meteorological parameters of the Tract C-a area will be monitored at three sites located at air quality monitoring stations 1, 2, and 3 (see Figure C-2).

Meteorological parameters will be measured with an automatic data acquisition system and will be recorded separately on strip chart recorders with 15-min and hourly average values. The meteorological parameters to be measured by each monitoring site are listed in Table C-5.

TABLE C-5. METEOROLOGICAL PARAMETERS PROPOSED TO BE MEASURED IN THE COMMERCIAL DEVELOPMENT PHASE MONITORING PROGRAM AT TRACT C-a

Parameter	Sites		
	1	2	3
Wind direction at 10 m (33 ft)	X	X	X
Wind direction at 60 m (197 ft)	X		
Wind speed at 10 m	X	X	X
Wind speed at 60 m	X		
Ambient air temperature at 10 m	X	X	X
Dewpoint at 10 m	X		
Total precipitation (heated gauge)	X		
Solar radiation level at 2 m (6.6 ft)	X		
Differential vertical temperature gradient at 10 m	X		
Differential vertical temperature gradient at 60 m	X		
Wind sigma metered at 10 m	X		

A significant part of the data analysis program will be spent in data validation to assure original data accuracy.

Water Resources

Baseline Data Gathering Program--

The baseline surface and groundwater data gathering program was conducted from March 1974 to September 1976. Much of the surface water data were gathered from U.S. Geological Survey (USGS) stream-gaging stations. The primary environmental contractor in the program was Limnetics. The main source of information on the program was supplied by the Final Environmental Baseline Report (1).

All collection procedures were designed for compliance with RBOSP needs, the Oil Shale Lease Environmental Stipulation, the Federal Register (Volume 39, Number 230, Part 3), the Tract C-a Exploratory Plan of May 1974, and subsequent conditions of approval from the Area Oil Shale Supervisor.

Surface water--Surface water flow and quality had originally been monitored at seven stream sites by USGS. Two of the seven had continuous flow and the other five had periodic flow. Three additional stream-gaging stations were implemented as part of the baseline program to monitor drainages in the proposed processed shale disposal site on 84 Mesa. The locations of these stations are presented in Figure C-3. Each station was equipped with a structure and automatic recording equipment for flow rate, temperature, and conductivity. Automatic sediment samplers were also installed at each station. In areas of relatively constant flow, automatic water quality samplers were set up to grab samples at regular intervals. The remaining streams had been set up to be sampled manually. The locations and USGS identification numbers for stream and rain-gaging stations during the baseline study are described in Table C-6.

Six rain gages were operated on and around Tract C-a for the purpose of collecting precipitation data. All six stations were operated by the USGS. The locations of these stations are shown in Figure C-3. Three of the gages were manually operated storage-type rain gages. The precipitation was measured at regular intervals. The other three gages were recording-type gages that recorded cumulative precipitation as well as precipitation rate over 5-min intervals.

Thirty-seven springs and seeps were identified and mapped (Figure C-4). Six of the 37 springs and seeps were analyzed for water quality and hydrology. The frequency of flow and quality measurements are not provided. The stations were monitored for the water quality parameters listed in Table C-7.

The three aquifer systems (upper and lower oil shale aquifers and the alluvial aquifers) were sampled using three methods. Water quality samples were collected from the circulation line generally four times during the drilling or coring of each hole. Samples were also collected for analysis during the aquifer testing program. Most of the water quality information, however, was derived from the monitoring program, where samples were collected by bailing. The results of wet chemical and spectrographic chemical analyses are stored on a computerized data base for ease in retrieval and analysis. The water quality data base consists of about 600 individual analyses so that, for meaningful interpretation, statistical methods were

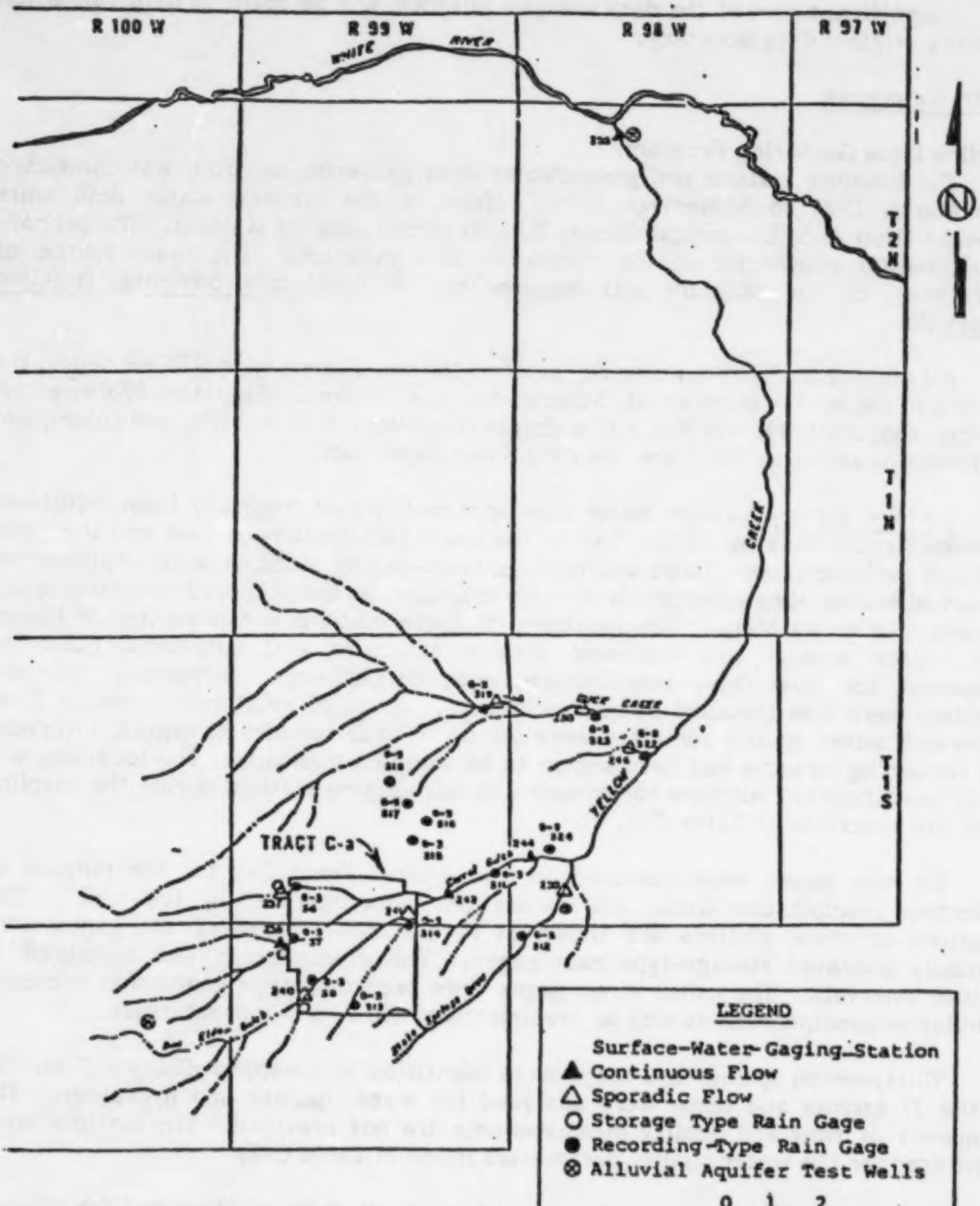
R 100 W
R 99 W
R 98 W
R 97 W
WHITE RIVER
T 2 N
T 1 N
T 1 S
CREEK
YELLOW
TRACT C-a
LEGEND
Surface-Water-Gaging Station
▲ Continuous Flow
△ Sporadic Flow
○ Storage Type Rain Gage
● Recording-Type Rain Gage
⊗ Alluvial Aquifer Test Wells
0 1 2
Miles

Figure C-3. Stream-gaging stations, rain-gaging stations, and alluvial aquifer monitoring holes at Tract C-a.

TABLE C-6. LOCATION AND USGS IDENTIFICATION NUMBERS FOR STREAM- AND RAIN-GAGING STATIONS AT TRACT C-a

USGS identification number and type of station	Location
Stream-gaging stations:	
09306237	Dry Fork near west line Tract C-a
09306235	Corral Gulch near west line Tract C-a
09306240	Box Elder Gulch near west line Tract C-a
09306242	Corral Gulch east of Tract C-a
09306230	Stake Springs Draw near confluence with Corral Gulch
09306255	Yellow Creek near White River, Colorado
09306241	Rinky Dink Gulch near east line Tract C-a
09306248	Upper Big Duck Creek north of 84 Mesa
09306250	Lower Big Duck Creek north of 84 Mesa
09306246	Tributary to Yellow Creek east of 84 Mesa
09306244	Corral Gulch south of 84 Mesa (near 84 Ranch)
Rain-gaging stations:	
Storage-type rain gages:	
09306235	Corral Gulch near west line Tract C-a
09306237	Dry Fork near west line Tract C-a
09306240	Box Elder Gulch near west line Tract C-a
Rainfall intensity and recording rain gages:	
09306230	Stake Springs Draw near confluence with Corral Gulch
09306255	Yellow Creek near White River, Colorado
No number	Cathedral Bluffs located in NW1/4, NW1/4, Sec. 14 T2S, R100W

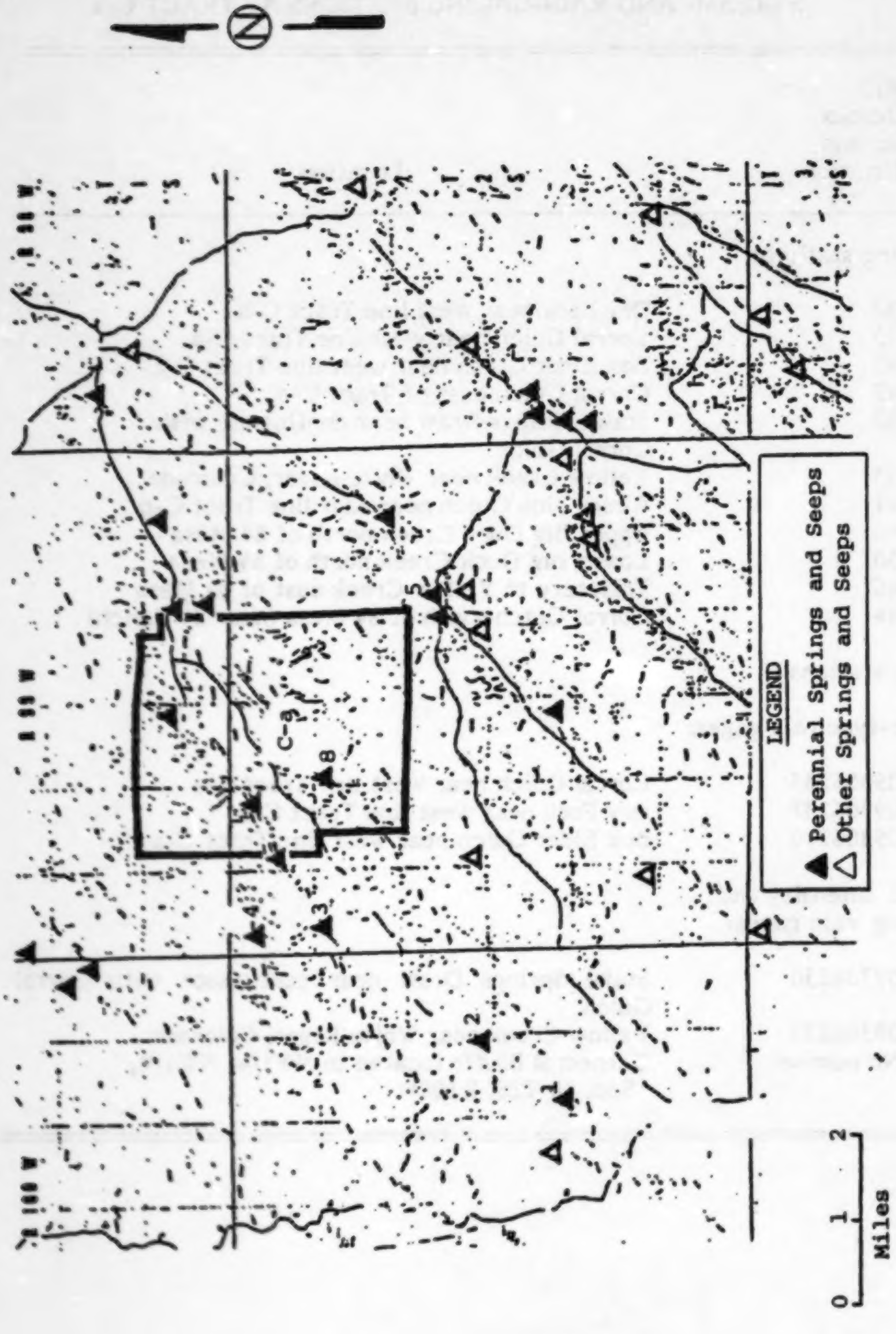
C-a
1
2
3
4
8
LEGEND
Perennial Springs and Seeps
Other Springs and Seeps
0
1
2
Miles

Figure C-4. Location map for Tract C-a baseline spring and seepage sampling sites.

TABLE C-7. SAMPLING SCHEDULE SUMMARY FOR SURFACE AND GROUNDWATER MONITORING PROGRAM AT TRACT C-a[a]

Parameter	Baseline program			Interim program		Modular development phase		Commercial development phase (proposed)	
		Groundwater							
	Surface water	First year	Second year	Surface water	Groundwater	Surface water	Groundwater	Surface water	Groundwater
Alkalinity (mg/l)	M	AM,DM	AQ,DS		O	QS	AQS,DS	QS	AQS,DS
Aluminum (g/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Ammonia (NH$_4$)(mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Arsenic (g/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Barium (g/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Beryllium (g/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Bicarbonate (mg/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Bismuth (g/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
BOD (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Boron (g/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Bromide (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Cadmium (g/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Calcium (mg/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Carbonate (mg/l)	M	AM,DM	AQ,DS	S	O	QS	AQS,DS	QS	AQS,DS
Chloride (mg/l)	M	AM,DM	AQ,DS	S	O	QS	AQS,DS	QS	AQS,DS
Chromium (g/l)	M	AM,DM	AQ,DS	S	O	QS	AQS,DS	QS	AQS,DS
COD (mg/l)	M	AM,DM	AQ,DS		O	S	AS;DS	S	AS,DS
Coliform, fecal (Col/100 ml)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Coliform, total (col/100 ml)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Color (PCU)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Conductivity, Spec. (mhos)	CM	AM,DM	AQ,DS	CS	AS	CS	AS,DCS	CS	AS,DCS
Copper (g/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Cyanide (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Dissolved oxygen (mg/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Fluoride (mg/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Gallium (g/l)	M	AM,DM	AQ,DS		O	QS	AQS,DS	QS	AQS,DS
Germanium (g/l)	M	AM,DM	AQ,DS		O	S	AQS,DS	S	AS,DS
Hardness (Ca, Mg)(mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Iron (g/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Kjeldahl nitrogen (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Lead (g/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Lithium (g/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Magnesium (mg/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Manganese (g/l)	M	AM,DM	AQ,DS		O	QS	AQS,DS	QS	AQS,DS
MBAS (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Mercury (g/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Molybdenum (g/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Nickel (g/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Nitrate (NO$_3$)(mg/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Nitrite (NO$_2$)(mg/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Nitrite plus nitrate (N)(mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS

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[a] A = Alluvial aquifer C = Continuously M = Monthly
D = Deep and shallow Oil Shale Aquifer S = Semiannually O = No sampling
Q = Quarterly

(continued)

TABLE C-7. (continued)

Parameter	Baseline program			Interim program		Modular development phase		Commercial development phase (proposed)	
		Groundwater							
	Surface water	First year	Second year	Surface water	Groundwater	Surface water	Groundwater	Surface water	Groundwater
Nitrogen, ammonia (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Nitrogen, organic (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Odor (severity)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Oil & grease (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Organic carbon (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Dissolved	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Suspended	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Total	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Pesticides (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
pH	CM	AM,DM	AQ,DS	CS	O	CS	AS,DCS	CS	AS,DCS
Phenols (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Phosphate (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Dissolved (PO_4)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Ortho (P)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Total (P)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Potassium (mg/l)	M	AM,DM	AQ,DS	S	O	QS	AQS,DS	QS	AQS,DS
Radioactivity	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Gross alpha (pc/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Radium 226 (pc/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Natural uranium (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Gross Beta (pc/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Strontium 90 (pc/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Cesium 137 (pc/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Selenium (μg/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Silica (SiO_2)(mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Silver (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Sodium (mg/l)	M	AM,DM	AQ,DS	S	O	QS	AQS,DS	QS	AQS,DS
Sodium adsorption Ratio	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Solids, dissolved (mg/l)	M	AM,DM	AQ,DS	S	O	S	AS,DS	S	AS,DS
Strontium (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Sulfate (mg/l)	M	AM,DM	AQ,DS	S	O	QS	AQS,DS	QS	AQS,DS
Sulfide (mg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Temperature (°C)	CM	AM,DM	AQ,DS	CS	AS	CS	AS,DCS	CS	AS,DCS
Tin (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Titanium (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Turbidity (JTU)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Vanadium (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Zinc (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS
Zirconium (μg/l)	M	AM,DM	AQ,DS		O	S	AS,DS	S	AS,DS

[a] A = Alluvial aquifer
D = Deep and shallow Oil Shale Aquifer
C = Continuously
S = Semiannually
Q = Quarterly
M = Monthly
O = No sampling

necessary. The results of wet chemical analyses of monitoring program samples were subjected to several quality assurance techniques. The balance between anion and cation totals was checked and found to be within 10 percent for most samples. For those samples where this 10 percent tolerance level was exceeded, the lab reports and lab workbooks were checked to assure that the difference was not result of a clerical error. As an additional check on the accuracy of the analyses, a comparison was made between calculated (sum of constituents) dissolved solids and residue on evaporation of filtered samples. The ratio of TDS to conductance was also examined, since specific conductance was measured in the field. To avoid the introduction of variance resulting from the sampling method, only those samples collected from the monitoring holes by bailing were used for population estimates. This was done because there is a high probability that many initial samples collected during the drilling and aquifer testing do not represent natural water quality in the aquifer.

Groundwater--Fifteen holes were dug in alluvium around Tract C-a, of which eight encountered water. Those wells were: G-S S7, G-S S8, G-S S11, G-S S12, G-S S19, G-S S22, G-S S23, and G-S S24. Continuous water level recorders were installed at four of the wells (S7, S8, S11, S12). Water quality samples were taken at all four sites during the monitoring program by bailing methods. The water quality parameters measured are listed in Table C-7. The samples were taken monthly during the first year. This frequency was decreased during the second year to quarterly sampling, except in the flash flood season when monthly sampling was necessary. The sampling schedule is summarized in Table C-7.

Twenty-five (upper and lower aquifer) water monitoring holes were drilled to levels between the stratigraphic limit above the Mahogany Zone to the top of the R-5 Zone. This has been noted as the Upper Aquifer Zone. The locations of these holes are shown in Figure C-5. Water level changes in the upper aquifer were determined using hydrographs, curve fittings, and residual analysis. Water quality analysis procedures were the same for upper aquifer testing as for alluvial aquifer testing. Water quality sampling began in July 1974 with core and drill sampling and continued on a monthly basis for 6 months. After 6 months, the sampling frequency was changed to once every 6 months (see Table C-7). The water quality parameters being measured were the same as for alluvium (see Table C-7).

The deep aquifer water monitoring program began in December 1974. Water samples were collected, and water levels were recorded monthly at 22 lower aquifer wells (22 dual upper and lower and 5 lower). Water samples were collected quarterly from March to August 1975 and semiannually thereafter. A listing of all the wells, upper and lower aquifer, is presented in Table C-8. The well locations are plotted in Figure C-5.

In addition to water quantity and quality measurements made on groundwater resources of the Tract C-a area, an analysis was performed to determine aquifer interrelationships including groundwater flow direction and storage capabilities.

Interim Monitoring Program--

The interim monitoring program was conducted during the lease suspension period from September 1976 to September 1977. The sources of information relating to the interim monitoring procedures were References 3, 4, and 5.

TABLE C-8. DRILL HOLE COMPLETION SUMMARY FOR TRACT C-a and VICINITY

Drill hole	Completion
30 on-tract holes:	
G-S 1	Upper and lower aquifers
G-S 2-3	Upper and lower aquifers
G-S 4-5	Upper and lower aquifers[a]
G-S 6	Upper and lower aquifers
G-S 7	Plugged and abandoned
G-S 8	Lower aquifer only
G-S 9	Upper and lower aquifers
G-S 10	Upper and lower aquifers
G-S 11	Upper and lower aquifers
G-S 12	Upper and lower aquifers[a]
G-S 13	Upper and lower aquifers
G-S 14	Upper and lower aquifers
G-S 15	Upper and lower aquifers
Am 4	Plugged and abandoned
CE-701	Upper aquifer pumping test
CE-702	Upper and lower aquifers
CE-703	Plugged and abandoned
CE-705-A	Upper aquifer pumping test
CE-707	Upper and lower aquifers
CE-708	Upper and lower aquifers
CE-709	Upper and lower aquifers
TO 1	Upper and lower aquifers
TO 2	Upper and lower aquifers
TO 3	Upper aquifer pumping test
G-S D16	Lower aquifer pumping test
G-S D17	Lower aquifer pumping test
G-S D18	Lower aquifer pumping test
G-S D19	Lower aquifer pumping test
5 off-tract holes:	
G-S M1	Upper and lower aquifers
G-S M2	Upper and lower aquifers
G-S M3	Upper and lower aquifers
G-S M4	Upper and lower aquifers
G-S M5	Aquifers, Uinta formation
Totals:	
22	Upper and lower aquifers
3	Upper aquifer only
5	Lower aquifer only
1	Uinta formation aquifers
4	Plugged and abandoned
35	Total number of holes

[a] Holes temporarily modified for upper aquifer pumping test.

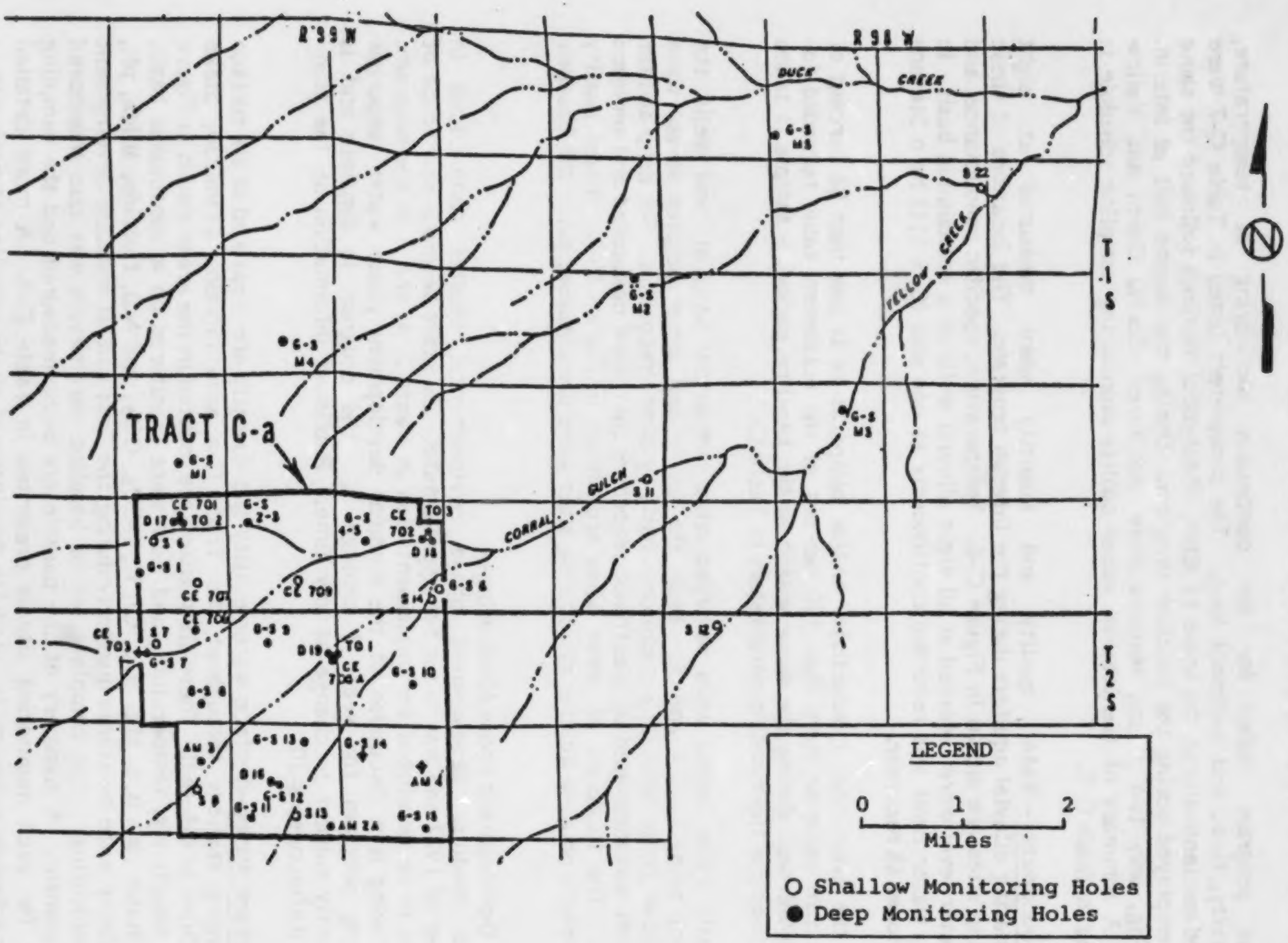
R 99 W
R 98 W
DUCK CREEK
YELLOW CREEK
CORRAL GULCH
T 1 S
T 2 S
TRACT C-a
G-S M1
G-S M2
G-S M3
G-S M4
G-S M5
S 22
S 11
S 12
CE 701
D 17
TO 2
G-S 2-S
G-S 4-S
CE 702
TO 3
D 18
S 6
G-S 1
CE 707
CE 709
G-S 6
S 14
CE 706
S 7
CE 703
G-S 7
G-S 9
D 19
TO 1
CE 700 A
G-S 10
G-S 8
G-S 13
G-S 14
AM 3
D 16
AM 4
S 8
G-S 11
G-S 12
S 13
AM 2A
G-S 15
LEGEND
0
1
2
Miles
○ Shallow Monitoring Holes
● Deep Monitoring Holes

Figure C-5. Location map for Tract C-a shallow and deep groundwater test wells.

Surface water--Eleven surface-water gaging stations were left operational during the first half of the interim monitoring program. Figure C-6 illustrates the locations of these sites, and they are identified in Table C-6.

The program called for the continuous monitoring of temperature, conductivity, flow, and sediment load. The parameters listed in Table C-7 were measured semiannually at the same 11 sites. Analytical methods followed the same format employed during the baseline program. During the second half of interim monitoring, only two gaging stations were monitored, Corral Gulch and Yellow Creek. A summary of the interim water quality monitoring sampling schedule is presented in Table C-7.

Groundwater--Water quality and quantity were measured at eight water-bearing alluvial aquifers during the interim program. The locations of these monitoring sites are shown in Figure C-6. Temperature, specific conductance, and static water level were recorded at all eight alluvial wells on a semiannual basis. In addition, water level was recorded continuously at one site (G-S S11) by a Stevens type F Model 68 recorder.

In the event that conductivity and/or temperature is less than 88 percent of the minimum value or more than 120 percent of the maximum value recorded for that alluvial well during the same season in the baseline period, a sample is taken and analyzed for the baseline parameters in Table C-7.

Static water levels were recorded on a semiannual basis at most wells, the exceptions being G-S 4 and 5. Both the upper and lower aquifer levels were monitored at these holes on a continuous basis by onsite recorders. The deep aquifer water level was measured by electronic recorders that were calibrated and serviced monthly. The locations of these holes are shown in Figure C-5. Water quality measurements on deep aquifer monitoring sites were discontinued after the baseline study.

Modular Development Phase Monitoring--

The modular development phase environmental studies commenced in September of 1977 and was to run for approximately 2½ years before a new scope of work was to be developed for implementation in Years 3, 4, and 5 of the program. The following is a discussion of the modular development phase water resources monitoring program for years 1 through 5. The program is dynamic and is consequently subject to change at any time. Published information on the study includes References 6-10.

Surface water--Surface water quality and quantity are measured at six surface water-gaging stations throughout the Tract C-a area (Station 09306230, Stake Springs Draw is deleted). These six stations are located in the areas shown in Figure C-7. Conductivity, temperature, and flow were monitored on a continuous basis, and the major ions (Ca, Mg, SO_4, Cl, K, HCO_3, CO_3, and Na), fluoride, silica, pH, and alkalinity were measured quarterly during the first half of modular development phase monitoring. The complete set of baseline parameters was also monitored every 6 months. A summary of the parameters being measured and the sampling schedule for each monitoring site is presented in Table C-9. A more detailed sampling schedule summary for modular development phase sampling at each site is presented in Table C-7. Chemical and physical parameters undergo correlation. If

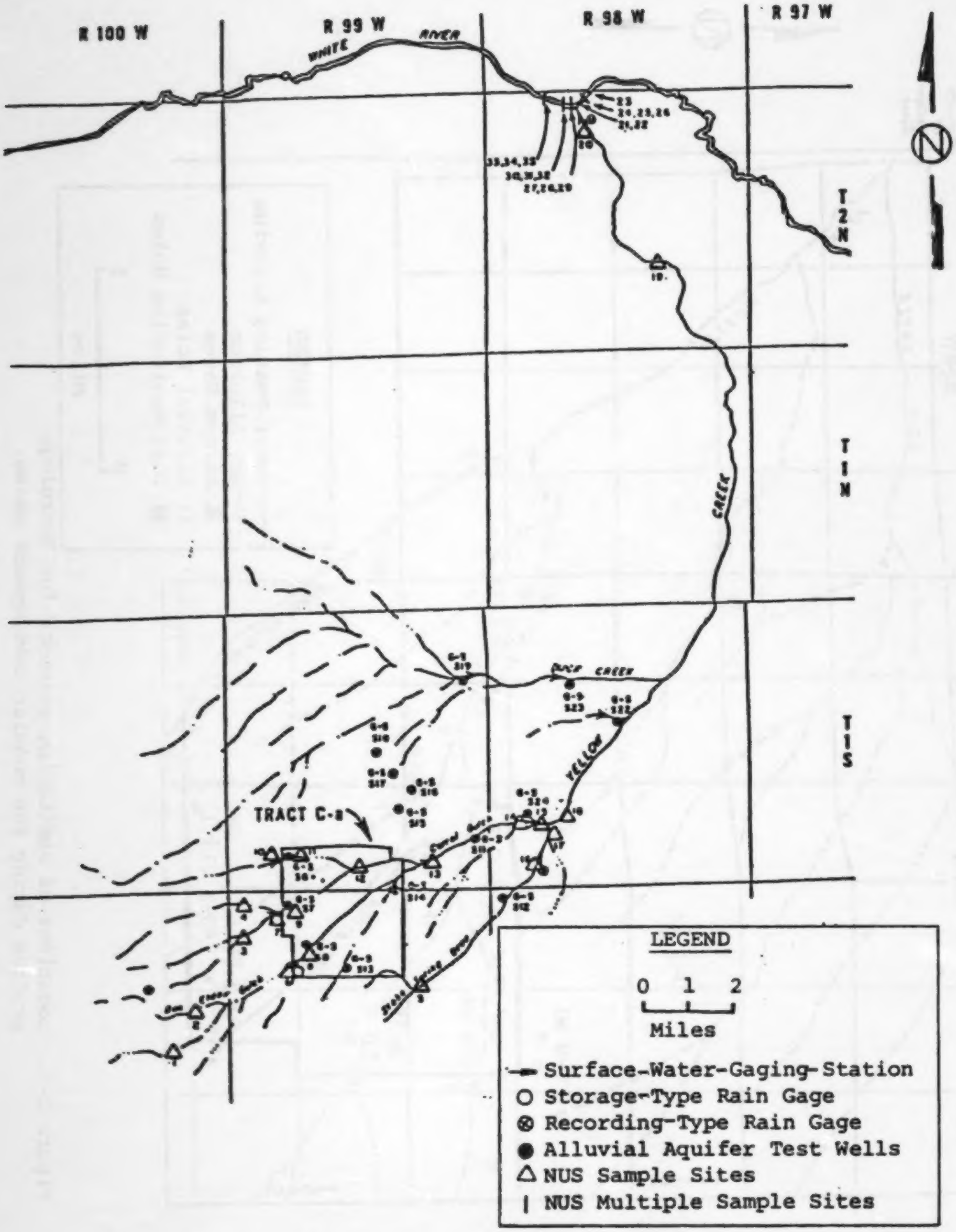
R 100 W
R 99 W
R 98 W
R 97 W
WHITE RIVER
T 2 N
T 1 N
T 1 S
CREEK
YELLOW
DUCK CREEK
TRACT C-a
LEGEND
0 1 2
Miles
Surface-Water-Gaging-Station
○ Storage-Type Rain Gage
⊗ Recording-Type Rain Gage
● Alluvial Aquifer Test Wells
△ NUS Sample Sites
| NUS Multiple Sample Sites

Figure C-6. Location map for Tract C-a interim surface-water-gaging and alluvial test wells.

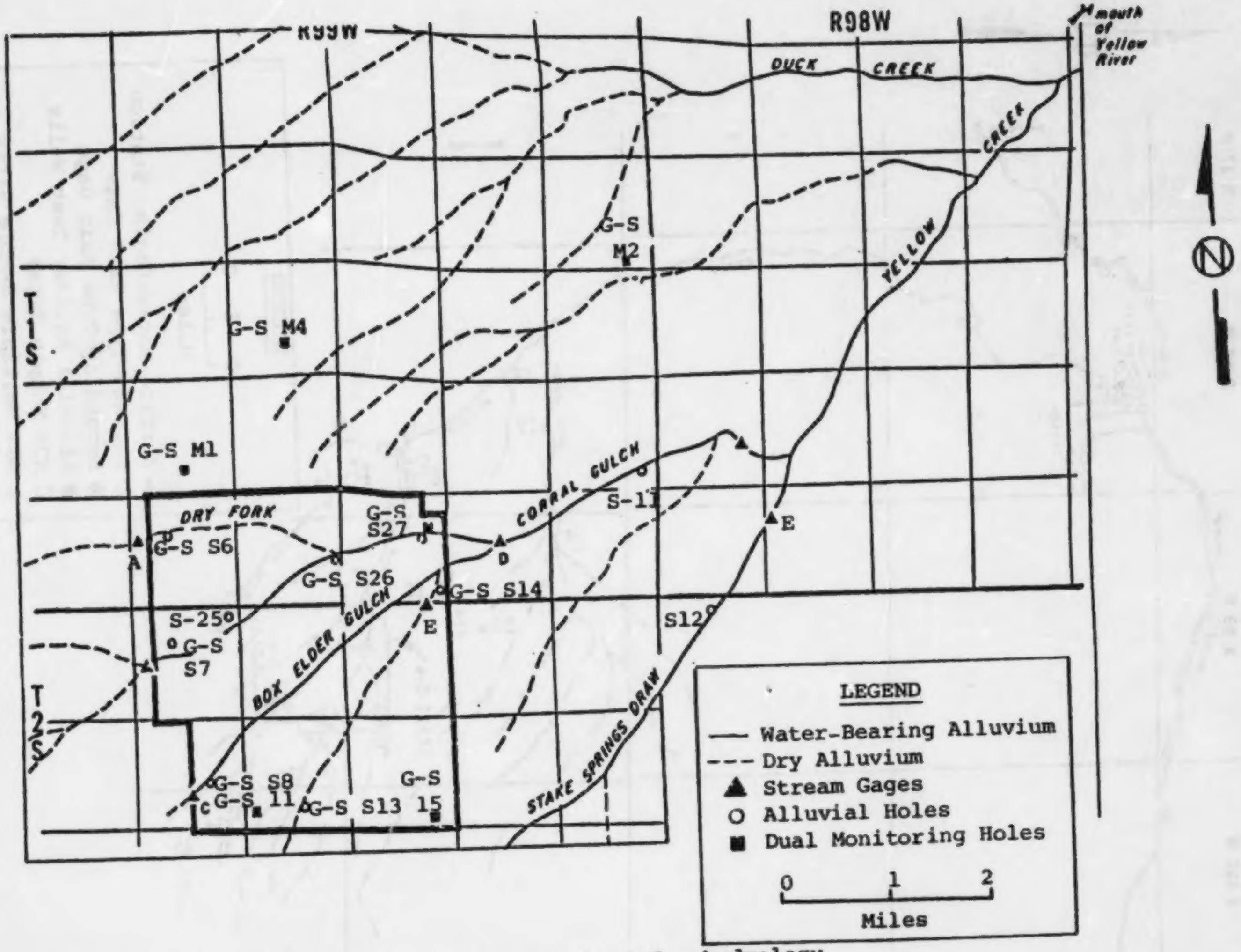
R99W
R98W
mouth of Yellow River
DUCK CREEK
YELLOW CREEK
T 1 S
T 2 S
G-S M2
G-S M4
G-S M1
DRY FORK
G-S S6
A
G-S S27
CORRAL GULCH
S-11
D
E
G-S S26
G-S S14
S-25
G-S S7
BOX ELDER GULCH
S12
STAKE SPRINGS DRAW
G-S S8
C
G-S 11
G-S S13
G-S 15
LEGEND
Water-Bearing Alluvium
Dry Alluvium
Stream Gages
Alluvial Holes
Dual Monitoring Holes
0
1
2
Miles

Figure C-7. Locations of monitoring stations for hydrology studies during the modular development phase.

TABLE C-9. SUMMARY OF HYDROLOGY MONITORING PROGRAM FOR THE MODULAR DEVELOPMENT PHASE PROGRAM AT TRACT C-a

Type of water	Sampling frequency Continuously or automatically	Quarterly	Semi-annually	Periodically
Surface water:				
Stream-gaging stations:[a]				
Sediment (periodically)	X(6)			
Conductivity	X(6)			
Temperature	X(6)			
Flow	X(6)			
Limited water quality		X(6)		
Baseline water quality			X(6)	
Springs and seeps:[a]				
Flow		X(6)		
Conductivity		X(6)		
Temperature		X(6)		
pH		X(6)		
Groundwater:				
Alluvial holes:[a]				
Water levels	X(3)	X(5)		
Limited water quality		X(8)		
Baseline water quality			X(8)	
Dual aquifer monitoring holes:				
Water levels	X(8)			
Dewatering Wells:				
Flow	X(12)			
Sediment[c]	X			
pH[c]	X			
Temperature[c]	X			
Conductivity[c]	X			
Water level alarm	X(12)			
Reinjection Wells:				
Water level alarm	X(12)			
Baseline water quality		X		

[a] When water is present.

[b] () Indicates the number of sampling sites.

[c] Composite sample before reinjection.

Note: Samples will be retained 30 days following submission of year-end report.

the continuously recorded parameters exceed the 1-percentile value for the cumulative frequency distribution of baseline for more than 3 days, the water is sampled and analyzed for the quarterly measured parameters in order to determine the aquifer source from which the anomaly originated. If the cause of the problem is determined to be due to some other occurrence, the complete set of baseline parameters will be measured.

Monitoring is carried out on six springs and/or seeps around the Tract C-a area. The locations of these monitoring sites is plotted on the map in Figure C-8. Flow, conductivity, temperature, and pH are measured quarterly at all six stations. Flow is measured by using a weir or flume. The data are recorded on 800 bpi magnetic tapes and analyzed to determine seasonal trends and the possible influence of dewatering/reinjection programs. The sampling schedule is illustrated in Table C-9.

Groundwater—Alluvial aquifers are monitored at eight locations around the Tract C-a area (Figure C-7). Water levels are measured continuously at three alluvial monitoring holes (G-S S7, G-S S26, G-S S27). The parameters measured quarterly are: water level, alkalinity, temperature, pH, conductivity, sodium, silica, fluoride, and the major ions (Ca, Mg, SO_4, Cl, K, HCO_3). The sampling schedule is illustrated in Table C-9. Two of the alluvial monitoring holes are new and are located in positions downstream of project development areas (mine shaft retention pond, surface disturbances). This allows for water quality deterioration determinations. The relationship between chemical and physical parameters will be subjected to correlation analyses.

During the second half of MDP monitoring (Years 3, 4, and 5) the alluvial wells monitoring program will be restructured to provide for monitoring of the parameters listed in Table C-7. The parameters will be measured at the following alluvial wells.

Continuously:

G-S S7, G-S S11, G-S S26, G-S S27

Quarterly:

G-S S6, G-S S8, G-S S13, G-S S14, G-S S25

Quarterly and Semi-Annual:

G-S S6, G-S S7, G-S S8, G-S S11, G-S S13, G-S S14, G-S S25, G-S S26, G-S S27

Deep groundwater levels are measured at six locations around Tract C-a. The locations of these six well holes are illustrated in Figure C-5. Deep groundwater quality measurements will be taken from dewatering well and mine discharges. Both the groundwater level and quality measurements will be made continuously. The quality parameters of the mine drainage to be measured continuously are: sediment, pH, conductivity and temperature. A composite dewatering well discharge will be measured semiannually for the baseline parameters listed in Table C-7. Flow meters will be utilized to determine dewatering rates. All chemical and physical parameters will undergo correlation.

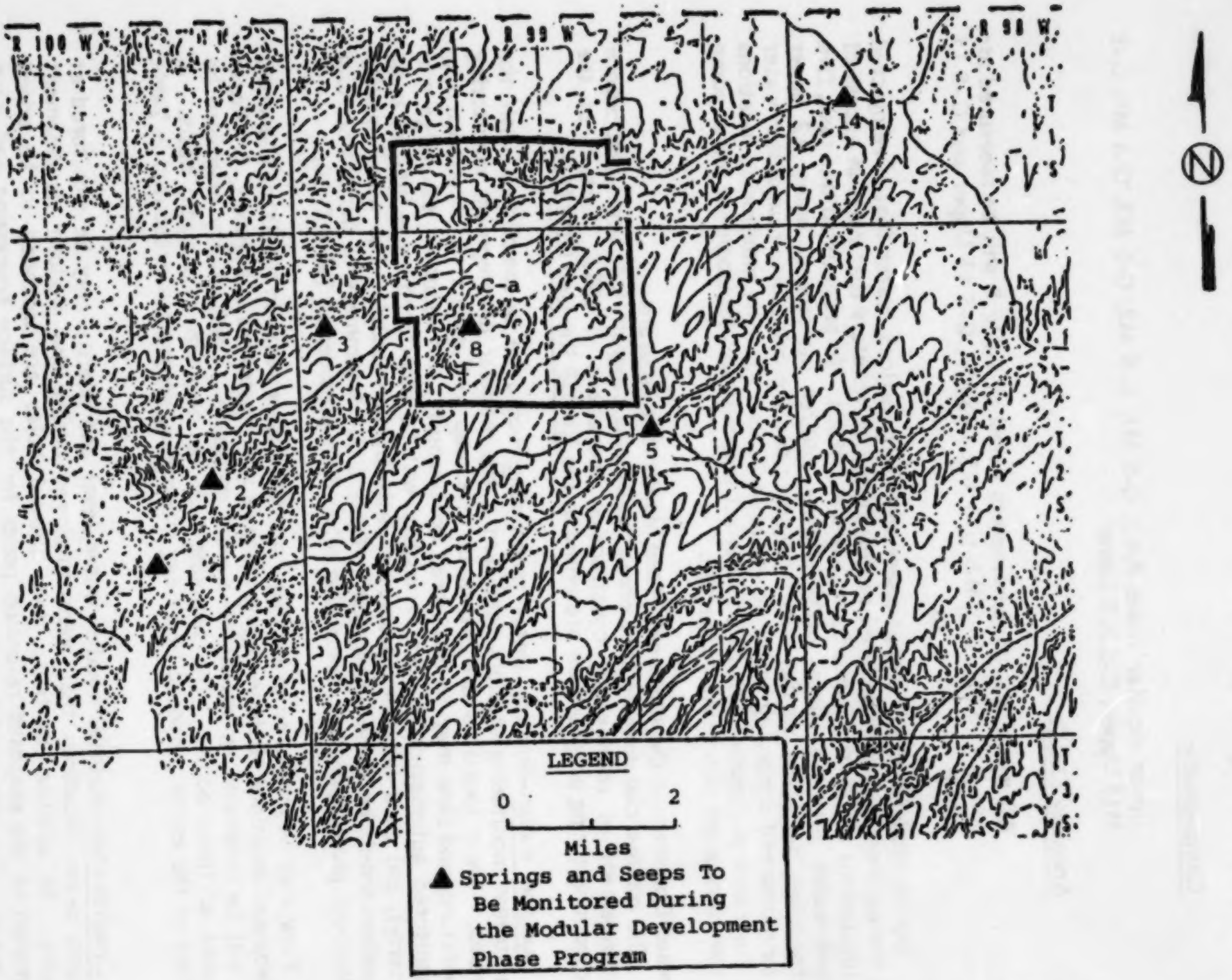
R 100 W
R 99 W
R 98 W
T 1 S
T 2 S
T 3 S
N
C-a
1
2
3
5
8
14
LEGEND
0
2
Miles
▲ Springs and Seeps To Be Monitored During the Modular Development Phase Program

Figure C-8. Location map for major Tract C-a spring and seep sampling stations.

At the conclusion of year 2 of the modular development phase, the deep groundwater monitoring program was conducted according to the schedule in Table C-9, and the following listing.

Continuously:

Upper Aquifer Holes Am3, G-S M1, G-S M2, G-S M3, G-S M4, G-S M15 Upper, G-S S15 Lower

Annually (July):

All water quality parameters listed in Table 8 will be measured at: Am-3, G-S M1, G-S M2, G-S M3, G-S M4, G-S 15 Upper and G-S 15 Lower

During modular development phase retort operations, water that is reinjected into the aquifers will be monitored to detect any parameters that exist in excess of the limitations set by the Subsurface Disposal Permit. To accomplish this task, five surface-water gaging stations, eight alluvial aquifer monitoring holes, 12 upper aquifer holes, one lower aquifer monitoring hole and the composite reinjection water will be monitored according to the schedule in Table C-9. The monitoring locations are illustrated in Figure C-7. NPDES permit and modular development phase pump test monitoring are also being conducted.

Proposed Commercial Development Phase Monitoring Program--

The commercial development phase monitoring program will begin just before commencement of commercial construction operations in 1982. Details of the proposed monitoring program are presented in the RBOSP Revised DDP (11).

Surface water--Surface water monitoring would be accomplished with the same stream monitoring stations used during the modular development monitoring programs. Their locations are shown on the map in Figure C-9. Conductivity, temperature, and flow may be monitored continuously, and sediment discharge will be monitored automatically. Water quality will be monitored on a limited basis (quarterly), and on a baseline parameter basis (semiannually). The water quality parameters should be those illustrated in Table C-7. A summary of the commercial development phase hydrology monitoring schedule is provided in Table C-10.

Flow may be measured at six major springs and/or seeps in the Tract C-a area. The proposed locations of these gaging stations are illustrated in Figure C-9. Water flow will be measured by means of a weir or flume. Conductivity may also be measured at these points. The sampling will be done on a periodic basis. A summary of the entire proposed hydrology monitoring program is presented in Table C-7.

Groundwater--Alluvial aquifer water level and quality may be monitored at the same seven locations that were employed during the modular development programs. In addition to those, two alluvial holes are intended to be added downstream of the proposed retention ponds for the surface processing and mine shaft areas. The proposed locations of these monitoring holes are illustrated in Figure C-9. Continuous water level recorders may be installed in the two new holes and in G-S S14. Water quality samples will be analyzed quarterly for conductivity,

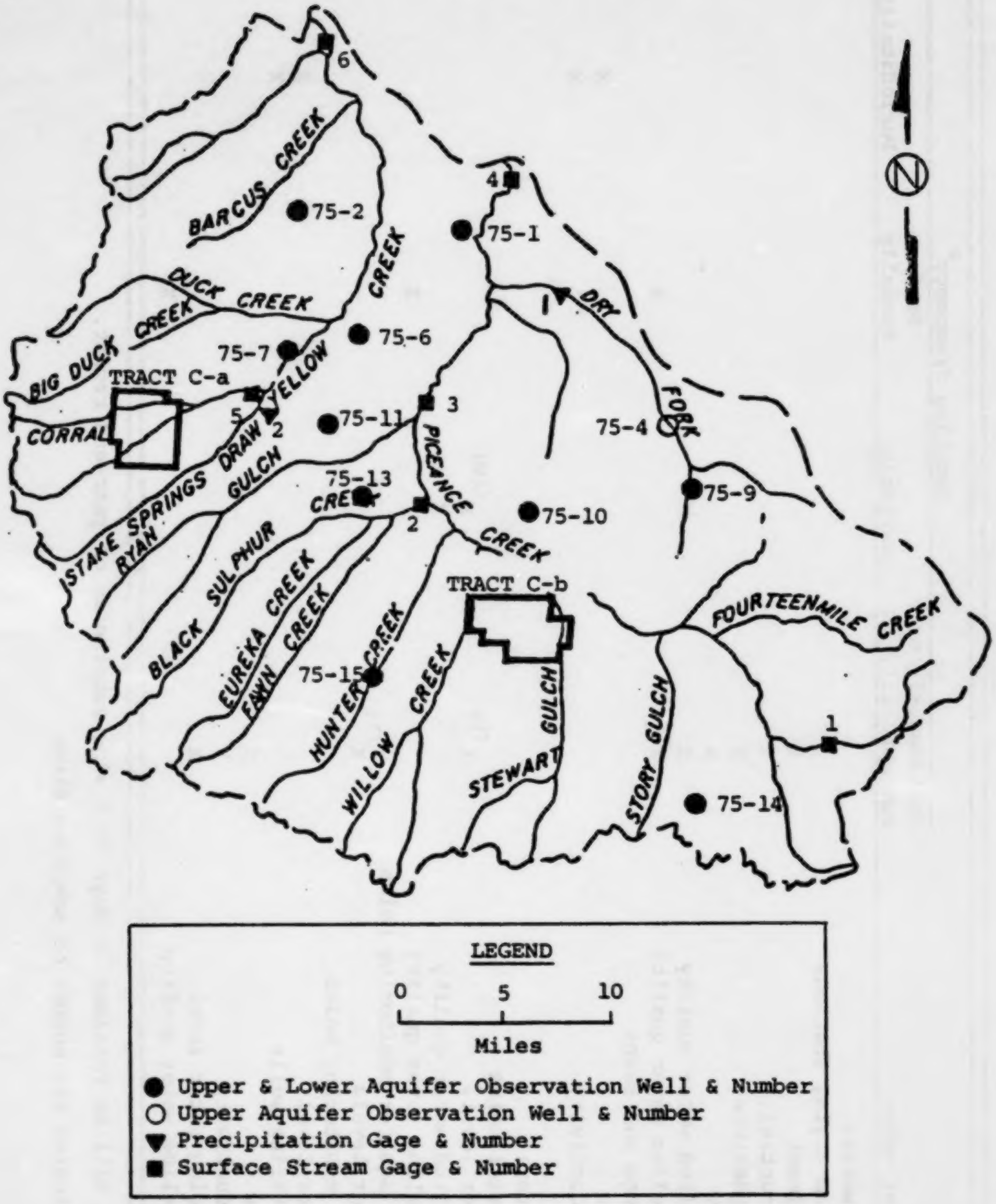
6
BARCUS CREEK
4
75-2
75-1
CREEK
DUCK CREEK
DRY
1
BIG DUCK CREEK
75-6
75-7
YELLOW
TRACT C-a
5
2
3
75-11
CORRAL
75-4
FORK
STAKE SPRINGS DRAW
RYAN GULCH
75-13
CREEK
PICEANCE
2
75-10
75-9
CREEK
BLACK SULPHUR
EUREKA CREEK
FAWN CREEK
HUNTER CREEK
TRACT C-b
FOURTEENMILE CREEK
75-15
WILLOW CREEK
STEWART GULCH
STORY GULCH
1
75-14
LEGEND
0
5
10
Miles
● Upper & Lower Aquifer Observation Well & Number
○ Upper Aquifer Observation Well & Number
▼ Precipitation Gage & Number
■ Surface Stream Gage & Number

Figure C-9. Location map for Tract C-a proposed commercial development phase groundwater test wells.

TABLE C-10. SUMMARY OF HYDROLOGY MONITORING PROGRAM FOR THE COMMERCIAL DEVELOPMENT PHASE PROGRAM AT TRACT C-a

Type of water	Sampling frequency[a] Continuously or automatically	Quarterly	Semi-Annually	Periodically
Surface water:				
7 Stream-gaging stations				
Sediment	X			
Conductivity	X			
Temperature	X			
Flow	X			
Limited water quality	X	X		
Baseline water quality	X		X	
6 Springs and seeps				
Flow				X
Conductivity				X
Groundwater:				
10 Alluvial holes				
Water levels	X(8)	X(10)		
Limited water quality		X		
Baseline water quality			X	
11 Dual aquifer monitoring holes				
Water levels	X(11)			
14 USGS monitoring holes				
Water level				X
Dewatering wells				X
Flow	X			
Conductivity	X			
Pumping water level	X			
Baseline water quality			X	

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[a] Samples will be retained 30 days following submission of year-end report.

[b] ( ) Indicates the number of sampling sites.

temperature, and the major ions. The baseline constituents will be measured semiannually (see Table C-7).

Deep oil shale aquifers are intended to be monitored at 11 RBOSP monitoring holes and 11 USGS observation holes. The dual aquifer monitoring hole being utilized during modular development monitoring will also be used on occasion. The locations of these holes are illustrated in Figure C-9. New monitoring holes would also be established before the elimination of C 702, G-S 6, and G-S 10 by mining.

Measuring devices will be used to measure pumping water levels in each dewatering well. Flow meters will also be installed to determine dewatering rates. Dewatering well and mine drainage discharges are intended to be monitored continuously for conductivity and temperature before reinjection. Initially, the baseline parameters will be analyzed on a monthly basis until a trend or stabilization of conditions is observed. Thereafter, baseline parameters will be monitored semiannually or when significant changes are observed in the conductivity values.

Biological Resources

Baseline Monitoring Program--

Information for this report was taken from two published documents--the RBOSP Final Environmental Baseline Report (1) and the RBOSP Environmental Baseline Data Accumulation Program (2). The baseline biological resource monitoring program was conducted from 1974 to 1976. The purpose of this program was to establish a data base on the abundance and diversity of vegetation, terrestrial vertebrates and invertebrates, and aquatic biota. The main environmental contractors on the project were NUS Corporation and Ecological Consultants, Inc.

Vegetation--Major vegetation types on Tract C-a were identified by aerial survey. In addition, vegetation sampling sites were selected for field verification. Each vegetation type was surveyed, and the most prevalent variants (such as pinyon-juniper with a sagebrush understory) were identified. The largest block of homogenous vegetation was selected for sampling. Sixty-two 106- x 6-m (348- x 20-ft) transects were established for sampling around Tract C-a, of which 35 were retained for sampling of herbaceous layers during later sampling periods. The sampling program was carried out during May, July, and September for the years 1975 and 1976.

Phytosociological data pertaining to the tree, shrub, and herbaceous strata were gathered and recorded from each transect. The phenologic condition of major plant species was recorded.

Plant specimens that were collected were identified according to plant species, date, location, habitat, elevation, and taxonomy. The plants were also preserved by pressing.

Range Studies--Field sampling was conducted to determine range, soil condition, and trend on the Tract C-a area. Dominant vegetation was verified by groundchecks. At the same time, plant composition, density, vigor, and soil condition trend were determined by direct observation.

Range utilization was also determined during the baseline biological resource program. Vegetation protection cages were distributed in pinyon-juniper, sagebrush, mixed brush, and grass vegetation types to supply protection to plants during the growing season. At the end of the growing season, these carefully positioned cages were removed, and the vegetative material inside was clipped, weighed, and compared to other vegetation plots that were similar in composition and position but that had been subjected to browsing and grazing.

Browse condition and utilization studies were conducted on a minimum of 100 sampling locations predetermined to support a preponderence of key species of particular interest. The analysis program was adapted from National Park Service methodologies (12).

A grazing exclosure was established on Tract C-a to monitor vegetation responses to exclusion of particular groups of grazing or browsing herbivores. An exclosure was constructed on the southwest quarter of Tract C-a. The structure contained three compartments, each designed to exclude particular groups of herbivores. Observation of the incremental forage production resulting from the protection being afforded made it possible to determine the relative importance of individual plant species to wildlife and to domestic and feral livestock and consequently allowed for definition of priorities for reestablishing plant species after disturbance.

Photoplots and remote sensing were used to monitor vegetation-type boundary changes.

Terrestrial Vertebrates and Invertebrates--Small mammals were collected for species identification, dominant habitat densities, and important species designation. The animals were collected by means of live and pitfall trapping systems. Trapping grids were designed to aid in determining population densities and ranges of the various animals. Small mammals were collected for identification of species, growth, abundance, etc., and were examined in the laboratory for stomach contents and reproductive efforts. In addition to trapping, small animals were monitored by night spotlight census. Bat investigations were also carried out during the summer months.

Aerial surveys for larger mammals were conducted along standardized transects during the months of October to April and June to September. The purpose of the survey was to estimate the distribution and abundance of mule deer, elk, and feral horses. Pellet groups were also analyzed to determine even more precisely the distribution, abundance and relative use of the area to mule deer. In addition, predators were monitored by use of scent-station visitation techniques, coyote siren census, live traps, aerial surveys, general observation, and winter track counts.

General avifauna were surveyed using the Emlen strip census procedure wherein an observer walks a line, records observations and locates observed avifauna in relation to the strip line. Upland gamebirds were censused using a vehicle to flush the birds in the early morning hours during the height of breeding season. Waterfowl were observed by monitoring the local ponds. Raptors were surveyed by use of aerial and ground surveys.

Reptiles and amphibians were observed by use of the line transect method and direct visits to breeding sites.

Terrestrial invertebrates were sampled using an assortment of trapping techniques, ranging anywhere from pitfalls to vacuums. Major taxa were identified and counted in the laboratory.

Domestic livestock were surveyed by means of aerial survey and utilization of existing information from the Bureau of Land Management. The possible presence of threatened and endangered species was investigated.

Aquatic Ecology--The aquatic biota baseline program covered the areas of physical and chemical water quality, plankton, periphyton, benthos, fish, and rare and endangered species. A total of 35 sampling stations was established for the sampling program. Samples were collected 12 times over the period of 2 years during the months of April, June, July, August, September, October, November, and December.

Phytoplankton was collected in a pump-type or bottle-type sampler concurrently with chemical samples. The samples were put in opaque bottles and preserved with Lugol's preservative until processed. Zooplankton samples (100 l or 26.5 gal or more) were pumped from a sampler into a carboy and filtered through a Wisconsin net (#25 mesh) and preserved in 5-percent neutralized formalin for laboratory analysis. Periphyton was collected by scraping selected substrates, and laboratory analysis was carried out for biomass, cell number, and chlorophyll determination. Periphyton samples were generally collected from natural substrates, but when this was not possible, artificial substrates were employed (styrofoam or glass). Benthic organisms were collected with either the modified Surber sampler, an Ekman grab, or a D-frame sampler. They were washed in a bucket fitted with a #30 sieve and preserved in neutralized 10-percent formalin. Standard methods of sample processing were used in the laboratory. Macrophytes were sampled using a random transect line system as outlined by Jessen and Lound (13). Fish were collected by electro fishing and/or seining. The fish were identified, and their reproductive efforts qualified. Efforts were made to determine the absences or presence of rare and endangered fish in the Tract C-a area.

A statistical analyses was performed on all gathered data.

Interim Monitoring Program--

The interim biological resource monitoring program was conducted for one year, from 1976 to 1977. The main purpose of the program was to keep current the data base that had been created during the baseline program. The sources of information on this program used here were References 3, 4, and 5.

Range Studies--Thirty sampling sites were established in areas of varying vegetation type (10 pinyon-juniper, 15 sagebrush, and five mixed brush) on Tract C-a and the 84 Mesa Study area to study range productivity and utilization (Figure C-10.)Two protected plots (0.9 m^2 each or 9.5 ft^2) and eight unprotected plots (permanently marked) were established at each sampling site. Range productivity and utilization were obtained by using the double sampling method. A visual estimate was made of production (weight to the nearest gram) of grass and forb species within the loop. Each species within the protected plots was clipped,

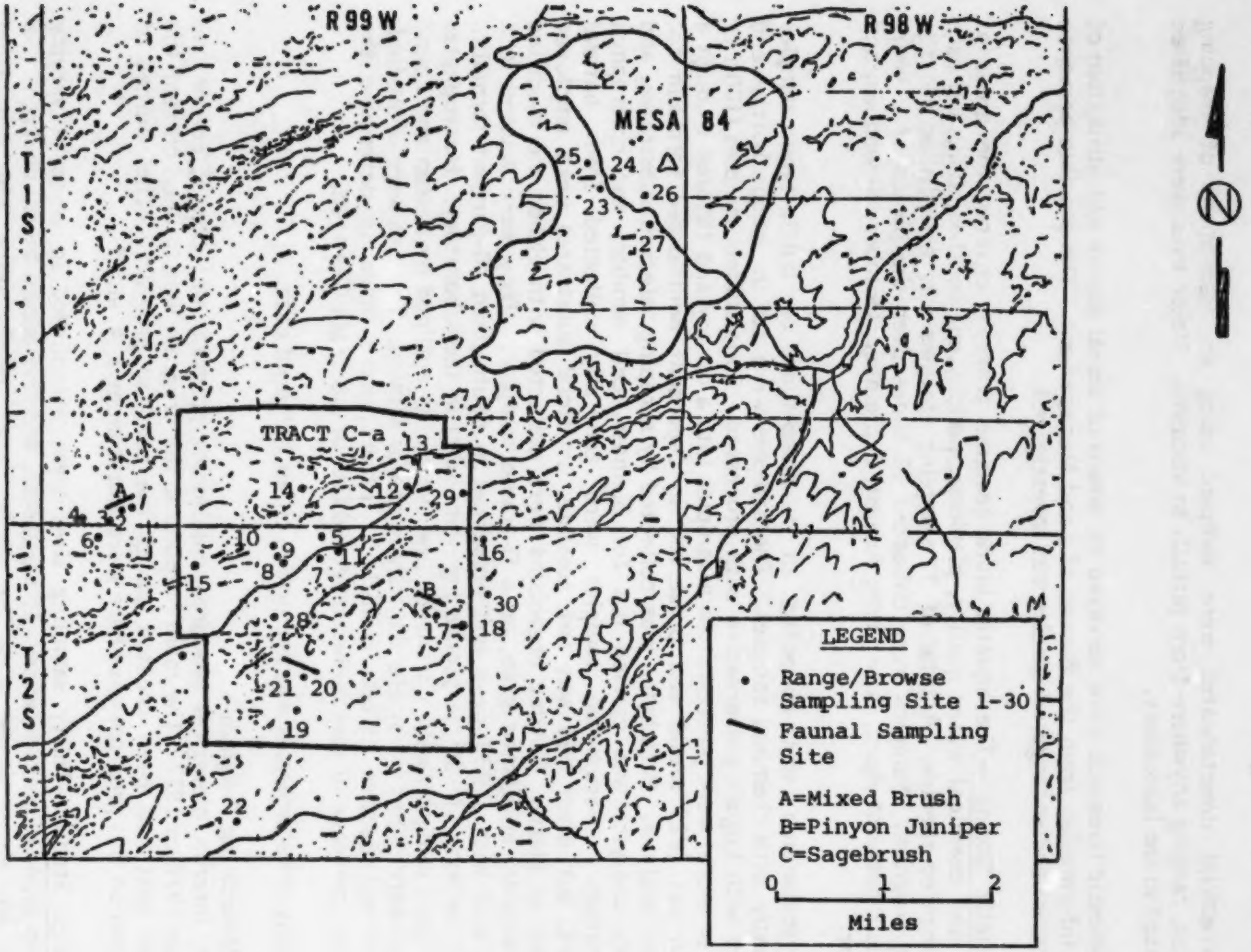

R99W
R98W
T1S
T2S
MESA 84
TRACT C-a
A
B
C
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
N
LEGEND
Range/Browse Sampling Site 1-30
Faunal Sampling Site
A=Mixed Brush
B=Pinyon Juniper
C=Sagebrush
0
1
2
Miles

Figure C-10. Location map for Tract C-a interim range/browse and faunal monitoring sites.

bagged separately, and weighed green. The weights were recorded. Species providing less than 1-percent of the biomass were recorded as present but were not weighed. Correction factors were calculated from the estimated green weights and actual green weights of the clipped plots.

$$\text{Correction factor} = \frac{\text{Actual green weight}}{\text{Estimated green weight}}$$

This correction factor was used to correct all estimated values. Clipped samples were air-dried for approximately 30 days and weighed to obtain moisture percentages. Air-dry forage productivity estimates were then computed from the moisture percentages and corrected estimates.

Percent utilization was calculated as follows:

$$\%\ \text{Utilization} = \frac{\begin{array}{c}\text{Average Productivity}\\ \text{per ungrazed plot}\end{array} \times \begin{array}{c}\text{Average Productivity}\\ \text{per grazed plot}\end{array}}{\begin{array}{c}\text{Average productivity}\\ \text{per ungrazed plot}\end{array}}$$

Field measurements were made at the end of the growing season in August 1977.

Browse condition and utilization studies were conducted on the same sampling sites as for the range production and utilization study. Browse plots were established within these site areas and examined before and after 1 year of use to measure utilization by deer and domestic cattle. At each sampling site, 25 individual key browse plants were examined. Sampling sites were established by arbitrarily selecting a shrub and permanently marking it. Subsequent shrubs were located along a transect by selecting the closest shrub within a 180° area oriented E-W of the center of the selected shrub.

During field sampling, five parameters were examined and recorded. They were: form classes, age classes, leader use estimates, hedging classification, and availability.

Terrestrial Vertebrates--Transects were established in the sagebrush, mixed brush, and pinyon-juniper areas in and around Tract C-a to study mule deer abundance and density. The approximate locations of these transects are illustrated in Figure C-10. Each transect included 25 circular plots of 1.13-m (3.71-ft) radius ($4\ m^2$ or $43\ ft^2$) each. Sample points were established every 20 m (65.6 ft) along the transect, and a search was made up to 6 m (19.6 ft) around each point to locate the center of the nearest pellet group. If a pellet group was not found, the transect point was considered the plot center. Slope, aspect, and phytosociology of the area were noted for each plot location. All transect points and all plots were marked with 1-cm x 25-cm (.4-in. x 9.8-in.) steel rebar stakes. The transect points were marked with waterproof ink on durable tags according to vegetation type (S for sagebrush, MB for mixed brush, and PJ for pinyon-juniper) and sequentially numbered from 1 to 25 in each vegetation type. The identification tags were attached to the stake on the side toward the pellet group plot to facilitate future plot location. All transect points were marked with fluorescent pink flags. Pellet groups were sprayed with orange enamel paint, and a similarly painted rock was placed in each group. The pellet plots were inspected in May and August 1977. New pellet groups and status of old groups were recorded. After each data collection period, estimates of deer density in each vegetation type were calculated on the basis of pellet group counts. Density data were compared with the browse utilization data and with the mule deer pellet group and aerial survey data from the baseline studies.

To study the number of small mammals in the Tract C-a area, 40 trapping stations were set up along two parallel lines, and each trapping station was equipped with three Sherman live traps. The locations of these faunal sampling sites are illustrated in Figure C-10. The mammals were trapped once in the late spring of 1977. All traps were prebaited at least 24 hr prior to the initiation of trapping. All traps were set and checked in the morning and evening. Trapping was conducted for three consecutive 24-hr periods. If on the third day, captures of new individuals of predominant species equaled or exceeded 50 percent of total captures for that day, the scope of work was amended with RBOSP approval to extend trapping until the number of new captures fell below 50 percent of total captures for each additional day (not to exceed 3 additional days of trapping). All animals captured were marked (if previously unmarked) with a unique toe clip combination and released. Data recorded for each individual animal captured included species, sex, toe clip number, reproductive status, and trap location. Three sets of trap lines were established during interim monitoring, one in each of the three major vegetation types (i.e., sagebrush, pinyon-juniper and mixed brush) on Tract C-a.

A 12-ha (30 acre) study plot was created in each vegetation type near the mule deer transects to study the avifaunal characteristics of the Tract C-a area. The study plot was divided into 1-ha (2.5 acre) units.

Each corner of the 1-ha (2.5 acre) units was marked for easy mapping, and the area was surveyed by a qualified observer. Data such as species encountered, location, nest location, nest contents, reproductive status of avifauna, wind speed, precipitation, and cloud cover were recorded. The results were intended to help determine the species density, territory sizes, and reproduction efforts of avifauna in the area.

Ground surveys on foot and vehicle were conducted during the sandhill crane migration period for the purpose of establishing use of the area by this species which when nesting in Colorado, is on the Colorado endangered species list. Observations as to weather conditions, behavioral patterns, etc. were noted and reported to RBOSP, Colorado Department of Wild Life, and the U.S. Fish and Wildlife Service as soon as was practical. Areas surveyed included Tract C-a, 84 Mesa, State Springs Pond, State Springs Draw, and Yellow and Duck Creeks.

Aquatic Ecology—During baseline studies it was determined that, because of the low abundance and species composition of phytoplankton, zooplankton, and macrophytes, these groups are of limited significance in the local aquatic ecosystems. Periphytic algae and benthic macroinvertebrates were determined to be important to the local aquatic ecosystems, and hence the monitoring of these communities was continued in the interim program.

Periphyton samples were collected from suitable spots located in three water channels (White River, Yellow Creek, and Corral Gulch) during the interim monitoring program. Samples were collected once in the spring and once in the fall and coordinated with water quality sample collections when possible. Samples were collected in duplicate from flat rock surfaces (50 cm^2 or 7.8 in.^{2}) with a knife and toothbrush and preserved for laboratory analysis. The analysis consisted of cell density, species composition, and relative abundance. The results were then compared to appropriate data from the baseline program. The preserved periphyton samples were diluted to a constant volume, and an aliquot was removed, centrifuged, and washed with distilled water. The samples were then dehydrated and stained in the centrifuge, using successive spinnings and decantings. The following (stain, steps, and alcohol) were used for the periphyton preparation:

a. Water rinse

b. Acid fuchsin stain (aqueous)

c. Water rinse

d. 50 percent isopropanol

e. 90 percent isopropanol

f. 100 percent isopropanol

g. 100 percent isopropanol

h. xylene rinse

i. xylene rinse

A number of drops of the final xylene-periphyton suspension were placed on a microscope slide with Hyrax, heated gently, and covered with an ultra-thin cover-glass. The final mounts were retained in the permanent voucher collection. Periphyton were counted from one randomly chosen transect at a magnification of 1000x (oil immersion). All organisms appearing in this field were identified and counted. The whole slide was then surveyed at 100x to identify and enumerate larger rare species. Counts were expressed as cells per unit area, and these data were used to compute relative abundance and species diversity.

Benthic samples were collected in replicate along three watercourses (White River, Yellow Creek and Corral Gulch) during the interim program. Samples were collected with a modified Surber sampler, washed through a U.S. Standard #30 sieve, and the retained specimen preserved with buffered 10-percent formalin. Standard methods of sample processing and analysis were used in the laboratory. The benthic samples were first agitated, and the organisms rinsed with a low-pressure fine spray into 20 cm (8 in.) #60 sieves to remove any fine sediments. The samples were then hand-sorted under dissection microscopes at 6X magnification. Samples were systematically searched, pushing examined portions aside, and the benthic organisms were removed with forceps. All organisms removed were stored in plastic capsules and 4-dram (0.25-oz) vials in 70 percent ethanol. With few exceptions, benthic organisms were identifiable to generic level without special preparation. The standard procedure was to identify the organisms to the lowest taxon possible. Identifications of individuals were usually made under the dissecting microscope or with temporary slides (under water) and a compound microscope. After identification and enumeration, specimens were stored in 70 percent ethanol in sample jars, collectively by sample replicate. A special reference or voucher collection was maintained apart from the other specimens. Only those individuals that were living at the time of collection, as indicated by presence of fleshy tissue, were enumerated for the purpose of estimating populations. Empty mollusc shells, exuvia, reproductive structures, etc. were retained as aids in identification and compilation of qualitative species lists, but they were not used for estimates of population densities. Benthic samples were taken twice a year (once in spring and once in fall) and coordinated with data from the water chemistry samples.

Modular Development Phase Monitoring Program--

The modular development phase biological resources monitoring program is currently taking place. It began in September 1977 and will run approximately 4 years. The NUS Corporation was the major consultant for the initial stages of the modular development phase. Documents reporting results of this program are References 6-10. A new program, the environmental monitoring program (EMP) was approved on April 26, 1979. The EMP does differ somewhat from the program described here.

Color aerial photography is taken of the Tract C-a area every 3 years, and these photographs are compared to earlier photos to determine any changes in the distribution of vegetation types. Color infra-red photography (1 cm = 79.2 m scale) is taken annually of the Tract C-a area to determine major vegetation stress areas. If stress conditions are noticed, additional sampling of the damaged area will be performed. Phytosociological studies are performed to determine herbaceous cover.

Range Studies--Thirty range sampling transects are established in various vegetation types (10 mixed brush, 10 pinyon-juniper, 10 sagebrush) to monitor range production and utilization in the Tract C-a area. The sites have been chosen at random in the same general location as the browse transects, and their locations are shown in Figure C-10. The sampling intensity should achieve a minimum accuracy of ± 25 percent of the mean 90 percent of the time.

Two caged plots (0.9 m^2 or 9.6 ft^2 in size) and eight unprotected plots are located at 10-m (33-ft) intervals along each sampling tansect. Forage is measured annually at the end of the growing season by using the double sampling method. All methods of sampling and analysis follow those outlined in the interim range study. The schedules of range monitoring programs are outlined in Table C-11.

Browse condition and utilization are measured along 30 transects (10 mixed brush, 10 pinyon-juniper, 10 sagebrush) located in the same general vicinity of the range transects. The approximate locations of these sampling sites are presented in Figure C-10. Browse sampling is visually performed in early May after deer have migrated through the Tract C-a area. All methods of sampling and analysis are comparable to those outlined in the interim range study.

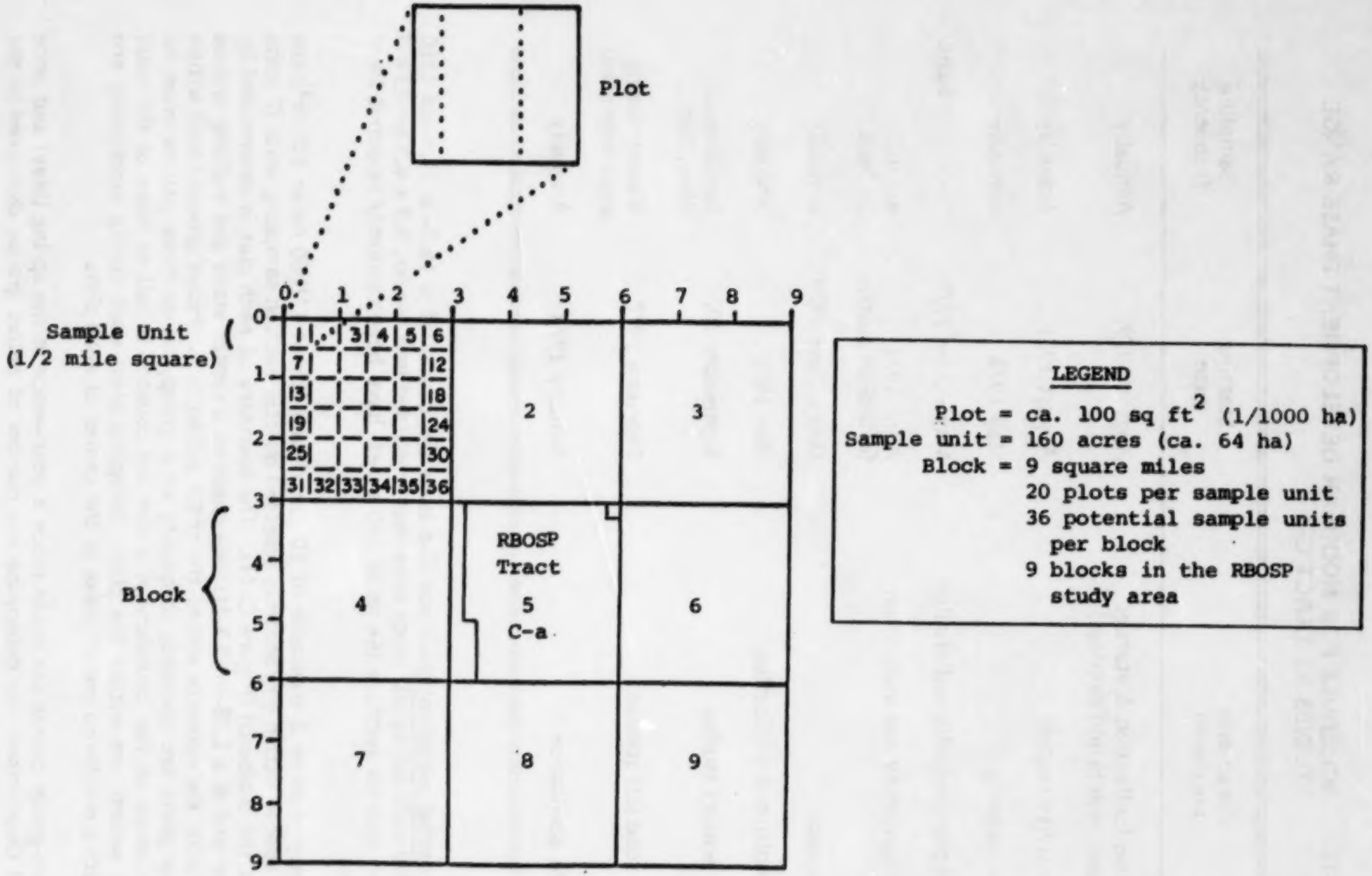
TABLE C-11. SCHEDULE FOR MODULAR DEVELOPMENT PHASE RANGE STUDIES AT TRACT C-a

Parameter measured	Starting date	Sampling frequency
Trace metals (collection & storage of soils and vegetation samples)	August 1979	Annually
Soil conductivity studies	August 1981	Annually
Vegetation mapping	May 1978	Annually
Vegetation phytosociological studies	May - June 1979	Once 3/yr basis
Range productibility and utilization	April 1978 (establish plots)	Annually (in Sept.)
Small mammals	May - June 1979	Annually
Browse condition & utilization	May 1978	Annually
Mule deer density studies	September 1977	Semiannually (May, Sept.)
Mule deer road kill studies	February 1977	Weekly during peak migration
Feral horse abundance	January 1978	Annually

Terrestrial vertebrates--Tract C-a is in the center of a 14.5- x 14.5-km (210 km^2) or 9x9 mile (81 sq mi) study area that is divided into blocks, 4.9 x 4.9 km (3 x 3 mi). Seven quarter sections (64 ha or 160 acres) have been randomly selected from each block.

Twenty plots or 2 transects of 10 plots each (about 1/1000 ha or 100 ft^2) are randomly spaced within 63 randomly selected quarter section sampling units (7 units in each of the 9 blocks) (Figure C-11). The boundary of each plot is determined by placing one end of a 1.78-m (5.8-ft) long chain on a center stake and walking around the stake with the opposite end of the chain pulled taut. Pellet groups found within the circular plots are counted; to qualify as a group, six or more pellets must be present. Groups on the boundary of a plot are counted if half or more of the total number of pellets are within the plot. Sampling plots used during monitoring are marked with a numbered metal stake at the center of each plot.

Pellet-group counts are made twice a year--once in the spring (May) and once in the fall (September)--to determine the number of pellet groups deposited in the


Plot
Sample Unit
(1/2 mile square)
Block
0
1
2
3
4
5
6
7
8
9
1
3
4
5
6
7
12
13
18
19
24
25
30
31
32
33
34
35
36
2
3
4
RBOSP
Tract
5
C-a
6
7
8
9

LEGEND

Plot = ca. 100 sq ft^2 (1/1000 ha)
Sample unit = 160 acres (ca. 64 ha)
Block = 9 square miles
20 plots per sample unit
36 potential sample units per block
9 blocks in the RBOSP study area

Figure C-11. Study area for mule deer pellet-group counts (RBOSP modular development phase monitoring program).

summer and during the migration and wintering periods. All pellet groups are removed from the plots as they are counted.

Aerial surveys are flown annually during the month of January to study feral horses. Transects along the same study area as for mule deer are flown, and feral horses are counted and their locations recorded. The aerial census is supplmented by general observations during terrestrial studies. This information will assist in the State's determination of feral horses in the area.

Aquatic ecology--A survey is conducted at six stations along stream courses in the Tract C-a area to determine what aquatic resources are available for the propagation of aquatic organisms. The locations of these sampling sites are shown in Figure C-12. The parameters being evaluated in this program include stream velocity, turbidity, pH, specific conductance, dissolved oxygen, total alkalinity, water temperature, depth, width, and stream substrata. These measurements are taken six times a year. The program schedule is summarized in Table C-12. The methods used for measurement of the parameters are:

Stream velocity	Gurley flowmeter
Stream substrata	Visual classification
Turbulence	Hach photometric turbidimeter
Dissolved oxygen	Alsterberg/Winkler method
pH	Portable meter
Specific conductance	Portable meter
Water temperature	Thermister
Depth	Chlorimetric (14)
Width	Chlorimetric (14)
Total alkalinity	Chlorimetric (14)

In addition to these parameters, certain water quality criteria are measured with the same frequency. These measurements are conducted at two sampling sites (Stations 27 and 29).

The monitoring for periphyton will be accomplished at the six sampling sites shown in Figure C-12. Sampling will be carried out six times a year. The methods of sampling and analysis are identical to those employed during the interim periphyton sampling program. Data are stored on magnetic tape. To achieve the objectives of the study, hypotheses are being tested using analysis of variance techniques. Sampling is intended to achieve an accuracy of ± 25 percent of the mean 95 percent of the time.

Benthic organisms are being sampled and analyzed from the same six sampling sites that are presented in Figure C-12. Sampling will be accomplished six times a year. During this program, benthos species diversity, density, and composition are being determined. The methods of sampling and analysis are identical to those implemented during the interim program. The data are stored on 9-track 800 bytes per inch, magnetic tapes. To fulfill the objectives of the study, several hypotheses are being tested using analysis of variance techniques. Sampling is intended to provide semiquantitative data which, when related to the physical, chemical and periphyton studies, will provide an overall assessment of the changes in the aquatic habitats on and near Tract C-a.

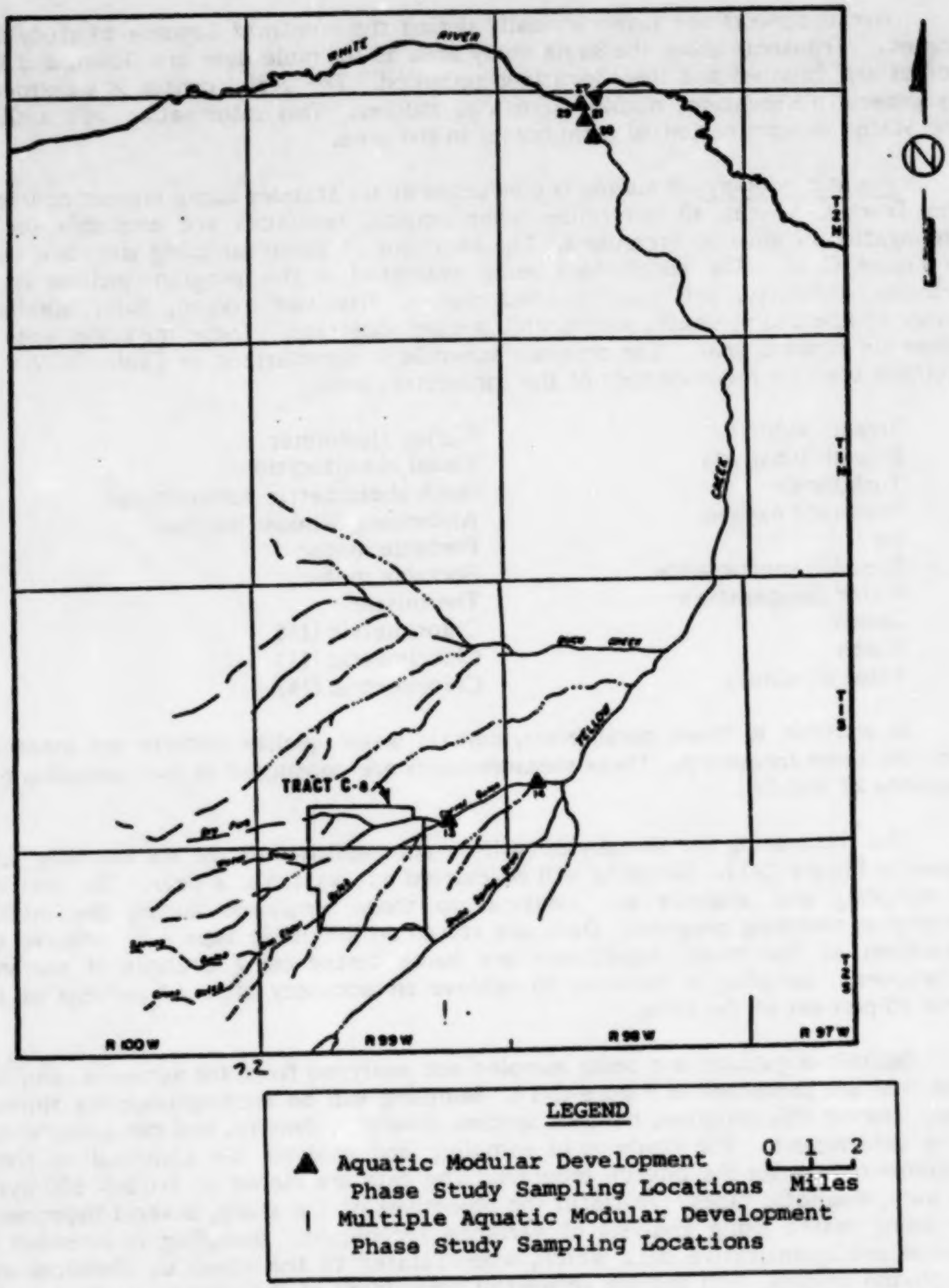

WHITE RIVER
29
21
30
T2N
T1N
CREEK
YELLOW
T1S
TRACT C-a
14
T2S
R 100 W
R 99 W
R 98 W
R 97 W
7.2
LEGEND
▲ Aquatic Modular Development Phase Study Sampling Locations
| Multiple Aquatic Modular Development Phase Study Sampling Locations
0 1 2
Miles

Figure C-12. Sampling site locations for aquatic ecology studies during the modular development phase.

TABLE C-12. MONITORING PROGRAM SCHEDULE FOR MODULAR DEVELOPMENT PHASE AQUATIC ECOLOGY STUDIES

Parameter	Location	Start date	Sampling frequency
Abiotic:			
Physical measurements:			
Stream velocity	Stations 13, 14 20, 21, 27, 29 (See Figure 6)	Oct. 1977	6 times/year (April, May, June, July, Aug., Oct.)
Turbidity			
Dissolved oxygen			
pH			
Specific conductance			
Water temperature			
Depth			
Width			
Stream substrate			
Water quality measurements (White River):			
Boron	Stations 27, 29 (See Figure 6)	Oct. 1977	6 times/year (April, May, June July, Aug., Oct.)
Calcium			
Chloride			
Fluoride			
Magnesium			
Nitrate			
Orthophosphate			
Potassium			
Total phosphate			
Silica			
Sulfate			
Sodium			
Alkalinity			
Total dissolved solids			
Biotic:			
Periphyton	Stations 13, 14 20, 21, 27, 29 (See Figure 6)	Oct. 1977	6 times/year (April May, June, July, Aug., Oct.)
Benthos	Stations 13, 14 20, 21, 27, 29 (See Figure 6)		6 times/year (April, May, June, July, Aug., Oct.)

Soil studies--Particulate releases 5 kg/hr (11 lb/hr) during the modular development phase will be quite low, and maximum concentrations are not expected to be sufficient to affect the soil stratum. However, accumulation over several years may result in measurable increases in these constituents. Therefore the following study is proposed.

Soil and vegetation samples will be collected before the first retort burn and stored. Samples will be collected annually (August) thereafter and stored. Concurrently, stack sampling of emission will be carried out.

If analysis of the samples taken after the burn of Retort 5 does not reveal a significant increase in trace metal content of affected area soils over the control area soils or over baseline samples, no further analysis of stored samples will be carried out. However, if significant increases are verified, then samples will be analyzed in decreasing order by age to determine the rate of increase by year.

Three control and three impact (treatment) sites will be selected for sample collection (Figure C-13). Control sites will be placed outside the tract and potential dispersion patterns. The impact sites will be located northwest and southwest of the emission sources in areas of predicted maximum short-term and annual concentrations. The sampling locations will be of sufficient size to assure thorough coverage of the potential impact zones. Locations of sampling sites will be reevaluated periodically on the basis of modeling data and source locations. If necessary, the sites will be relocated.

Ten soil samples will be collected during August of each year from the surface soils (0 to 10 cm or 0 to 4 in.) of each site. Five composite vegetative samples each of sagebrush and a metal-concentrating plant (e.g., Astragalus) will be collected at each site from the current year's growth.

If significant levels of trace metals are released from stacks, then soil samples will be immediately analyzed for those elements identified in the emissions (e.g., Sb, As, B, Cd, F, Hg, Se, Mo, and V). If trace metal levels in the impact site soil samples are shown to be significantly greater than levels that were present during the baseline studies or in the control samples, then vegetation samples will be analyzed to determine if trace metals have been taken up into the food chain.

Modeling efforts indicate that the maximum concentrations of salt drift are expected to occur immediately adjacent to the cooling tower . The areas of maximum deposition are limited to within the tract boundaries. Large deviations from the projected dispersion pattern are not expected because of the large size of the salt droplets. Therefore, specific control and impact sites (0.8 x 0.8 km or 0.5 x 0.5 mi, Locations 5 and 6) have been selected in the expected maximum and minimum salt deposition areas (Figure C-13).

The control site was selected in an area where soils (Rentsac and Rentsac-Piceance) are similar to those in the impact area. Baseline studies indicate that both soil series have low soil conductivities (Rentsac = 1.6 µmhos/cm (4.1 µmhos/in.); Piceance = 1.3 µmhos/cm (3.3 µmhos/in.) based on a saturated paste sample). Therefore if appreciable salt deposition occurs, detection of a change in soil conductivity should be possible.

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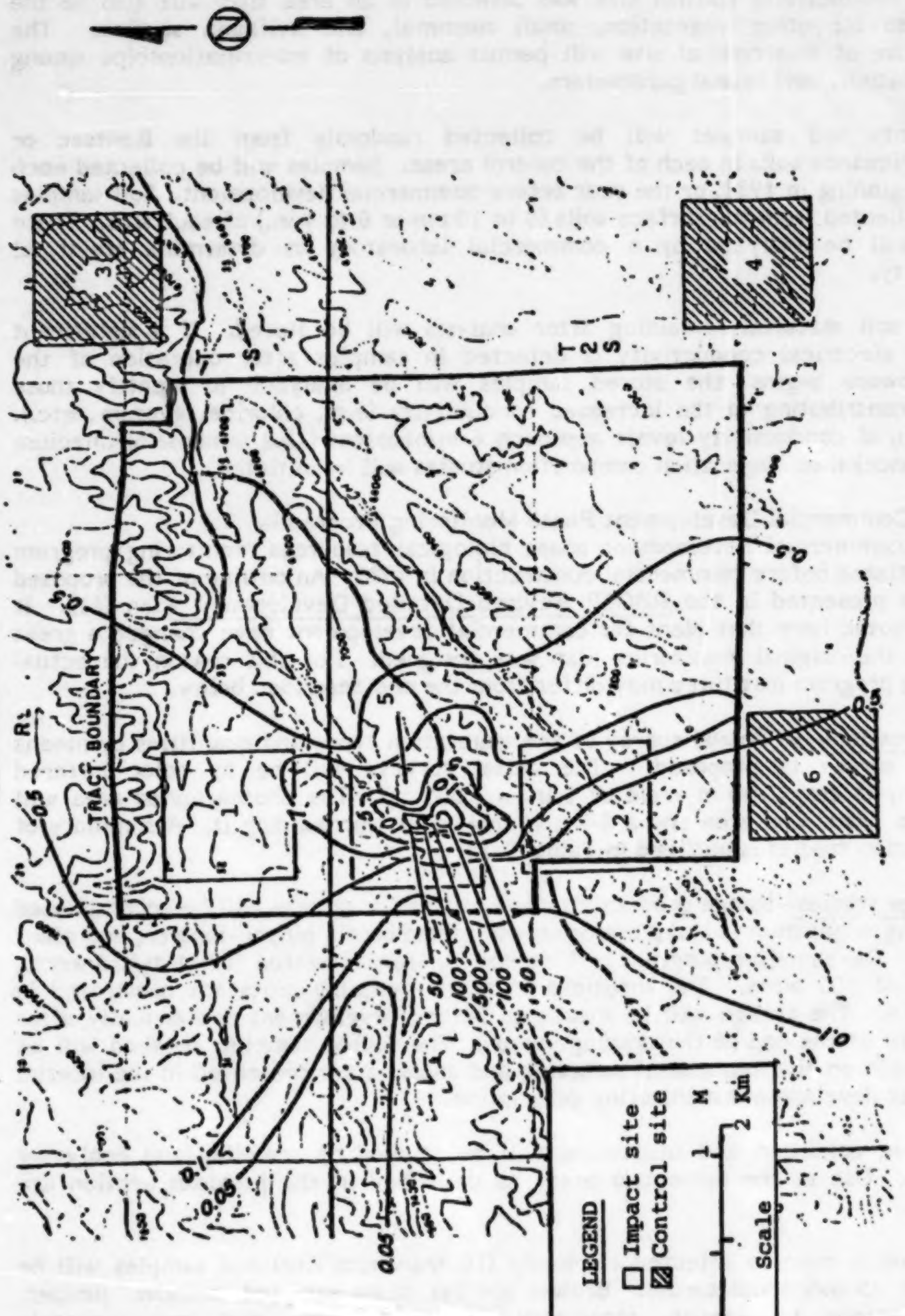
N
TRACT BOUNDARY
R1
T 2 S
1
2
3
4
5
6
0.05
0.1
0.5
1.0
5
50
100
500
LEGEND
☐ Impact site
▨ Control site
Scale
0 1 2 Km

Figure C-13. Tentative locations of soil sampling sites; Nos. 1 through 4 are trace metal accumulation sites, and 5 and 6 are conductivity sampling sites. Isopleths represent predicted pattern of salt disposition from cooling towers (g/m^2).

The conductivity control site was selected in an area that will also be the control site for other vegetation, small mammal, and avifauna studies. The multiple use of this control site will permit analysis of interrelationships among soil, vegetation, and faunal parameters.

Twenty soil samples will be collected randomly from the Rentsac or Rentsac-Piceance soils in each of the control areas. Samples will be collected each August beginning in 1981, or the year before commercial development. Soil samples will be collected from the surface soils (0 to 10 cm or 0 to 4 in.) of each site. These samples will be analyzed by a commercial laboratory to determine electrical conductivity.

The soil material remaining after analysis will be stored. If a significant change in electrical conductivity is detected in samples after operation of the cooling towers begins, the stored samples will be analyzed to identify those elements contributing to the increased conductivity (e.g., chloride, gypsum, etc.). In addition, if conductivity levels approach 6 mmhos/cm (15.2 mmhos/in) (medium salt tolerance) then vegetation composition studies will be initiated.

Proposed Commercial Development Phase Monitoring Program--

The commercial development phase biological resources monitoring program will be initiated before commercial construction in 1982. An outline of the proposed program is presented in the RBOSP Revised Detailed Development Plan (11). It should be noted here that plans for commercial development have changed a great deal since the original monitoring plan was designed. For this reason the actual monitoring program instituted may differ from the one described below.

Vegetation--An annual survey of the vegetation types and quantities by means of aerial survey is proposed. The aerial surveys will be by color infrared photography (1 cm = 240 m scale or 1 in. = 2,000 ft). The photographed area will include the Tract C-a area and a 8-km (5-mi) radius surrounding it. A summary of the vegetation studies is outlined in Table C-13.

Range studies--Range productivity and utilization studies will be accomplished by surveying vegetation in three major areas: mixed brush, pinyon-juniper, and plant sagebrush. The sampling program will employ 10 transects/area (10 plots/transect), or a total of 100 plots. The locations of these sampling plots are illustrated in Figure C-14. The forage will be measured before development and annually after development at the end of the grazing season. The double sampling method will be used. Details on the methods of sampling and analysis are presented in the interim and modular development monitoring description.

Browse condition and utilization will be studied by sampling and analyzing vegetation. Use in the same two areas as described in the previous section are analyzed.

Transects may be selected randomly (10 transects/site) and samples will be taken from 25 individual shrubs. Browse species to be sampled include: juniper, pinyon, antelope bitterbrush, snowberry, big sage brush, and true mountain mahogany. Transects will be selected randomly. Sampling will be conducted in early May, after deer migration. Form, class, age, leader use, hedging, and availability will be measured.

TABLE C-13. SUMMARY OF PROPOSED COMMERCIAL DEVELOPMENT PHASE TERRESTRIAL MONITORING PROGRAM AT TRACT C-a

Sampling program	Parameter	Sampling frequency (years	Sampling technique	Sampling intensity	Data analyses
Vegetation	Distribution of vegetation type	Before, 1, 2, 3, 4, 5	Aerial photographs	Tract C-a and 8 km radius	Preparation of vegetation map; ground truthing
	Productivity & utilization	Before, 1, 2, 3, 4, 5	Double sampling method	10 Transects/sample site	Analysis of variance multiple range test
	Browse condition & utilization	Before, 1, 2, 3, 4, 5	Cole (16)	10 Transects/sample site	Analysis of variance multiple range test
Soils	Conductivity	Before, 1, 2, 3, 4, 5	Soil cores (0-10 cm)	20 Samples/sample site	Analysis of variance
	Trace elements (As, B, Se, etc.)	Before, 1, 2, 3, 4, 5	Soil cores (0-10 cm)	20 Samples/sample site	Analysis of variance
Fauna	Small mammals Species composition Index of abundance	Before, 1, 3, 5	Pit trapping, live trapping	5 Groups (2 transects of 10 traps/group)[a]	Regression analysis; F-test; analysis of variance (index of abundance)
	Avifauna Species composition	Before, 1, 3, 5	Breeding bird mapping technique	12-45 ha (30-105 acres) (depending on size of area)	Regression analysis; analysis of variance (for density only)
	Map of territories Density of breeding		Graul (15); Hall (18); Robbins (17)	Divided into 1-ha subunits; 6 replicates of subunits[a]	
	Birds				
	Mule deer Density estimates	Before, 1, 2, 3, 4, 5	Pellet group counts	23 km-sq study area divided into blocks; quarter-sections within blocks include 20 plots[a]	F-test; regression analysis; analysis of variance
	Feral horses	Before, 1, 2, 3, 4, 5	Aerial census	Mule deer study area	Report observations

[a] Sampling intensity will be determined during the first year of study.

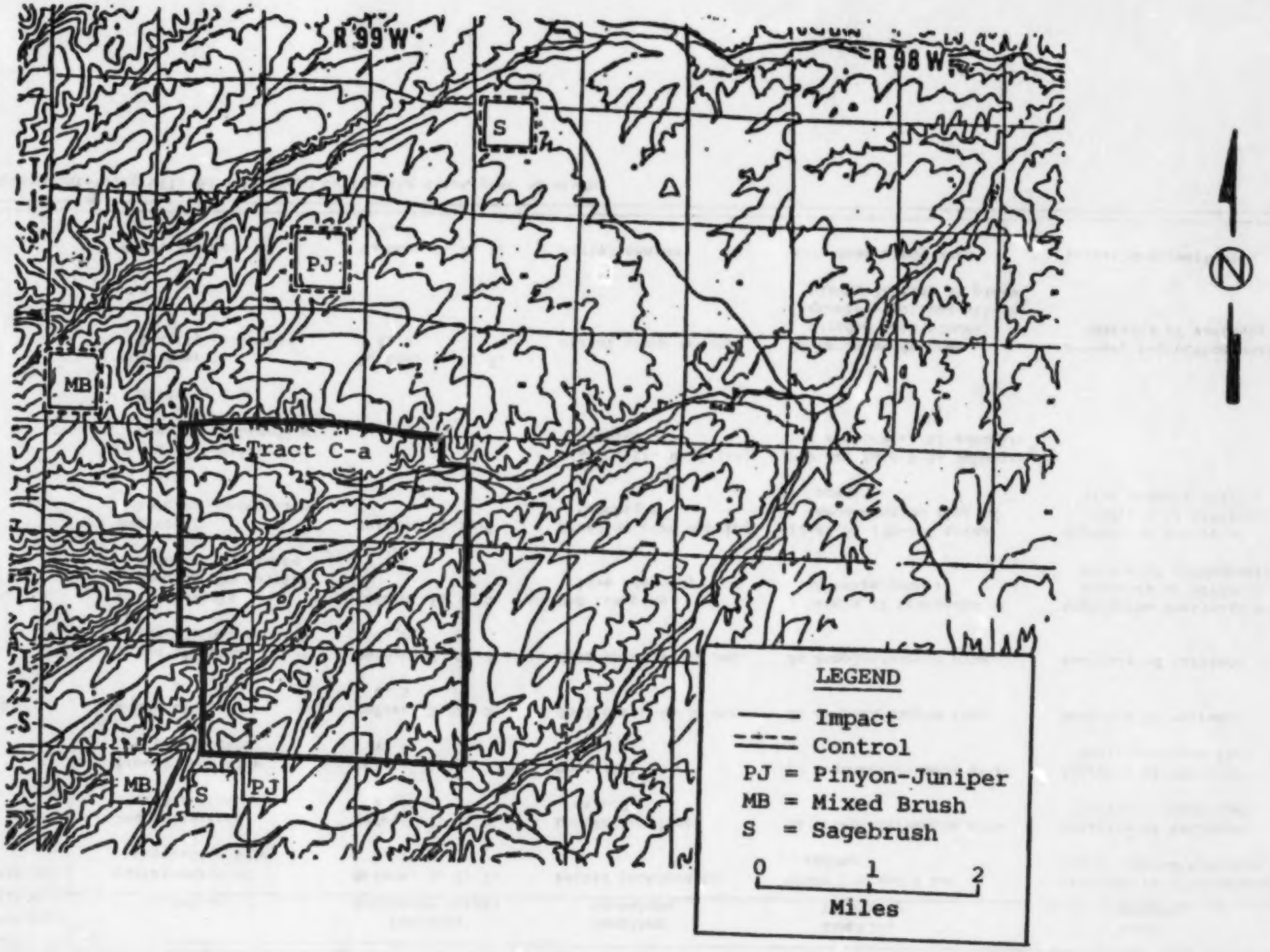
R 99 W
R 98 W
T 1 S
T 2 S
Tract C-a
S
PJ
MB
MB
S
PJ
N
LEGEND
Impact
Control
PJ = Pinyon-Juniper
MB = Mixed Brush
S = Sagebrush
0
1
2
Miles

Figure C-14. Location map for Tract C-a vegetation monitoring sites for the proposed commercial development phase biological resource monitoring program.

Terrestrial vertebrates and invertebrates--Sherman live traps and pit traps may be utilized to monitor the abundance of small mammals in the area. The total number of traps and number of sampling days required is yet to be determined. Traps will be checked in the morning and evening. Animals captured will be identified, sexed, aged, and released at the capture point.

The breeding bird mapping technique is intended to be utilized to determine the location, species, and breeding activity of observed avifauna. Each study unit will be divided into 1-ha (2.47-acre) subunits. An observer will walk the area and record the required information. This information will be documented on maps. Additional information will be collected by general observation. The frequency of monitoring activities has not yet been determined.

Mule deer inventories will be conducted on Tract C-a by means of pellet group counts. Tract C-a will be in the center of a 15- x 15-km or 225-km^2 (9- x 9-mile or 81 sq mi) study area which will be divided into blocks (approximately 2.6 sq. km or 1 sq mi each). Quarter sections (64 ha or 160 acres) will be randomly selected from each block. The number of quarter sections to be used will be determined after results of the baseline studies can be observed. The methods of sampling and analysis are identical to the methods described in the baseline program. The program will be started before modular development phase construction and will continue annually thereafter.

The abundance of feral horses occurring in the Tract C-a area will be determined by general observations, aerial overflights, and State and Federal agencies. The information will be collected and compiled annually.

The number of cottontails and jackrabbits will be determined by visual search and observation. Predetermined routes will be driven at a speed of 16 kmph (10 mph).

Aquatic ecology--On and near Tract C-a, two aquatic habitat types have been observed--ponds and spring brooks. Based on baseline observation, 10 sampling sites have been selected for the monitoring of RBOSC water control effectiveness and for determination of possible impacts. The locations of these sites are the same as described in the modular development phase program.

Selected physical characteristics of streams in the Tract C-a area will be measured at the sites. The parameters to be measured include: stream velocity, turbidity, substrate, dissolved oxygen, pH, specific conductance, water temperature, depth, width, and alkalinity. The proposed method of measurement for each constituent is illustrated below. Sampling frequency will be five times a year.

Velocity	Gurley flowmeter
Turbidity	Hach photometric turbidimeter
Stream substrate	Visual observance
Dissolved oxygen	Alsterberg/Winkler method
pH	Portable meter
Specific conductance	Portable meter
Water temperature	Thermister

Depth	Colorimetric (14)
Width	Colorimetric (14)
Alkalinity	Colorimetric (14)

Water quality--Water quality parameters in the aquatic biological resources areas of Tract C-a may be measured at the locations described in Figure C-12. The parameters would be measured five times a year. The constituents to be measured will include calcium, chloride, boron, fluoride, magnesium, potassium, sodium, sulfate, nitrate, orthophosphate, total phosphate, and silica.

Periphyton samples will be taken from the sampling points illustrated in Figure C-12. Replicate samples will be taken from natural substrates five times a year and will be analyzed to determine relative abundance, diversity, and biomass. Field and laboratory studies will be the same as those used during baseline studies.

The composition, abundance, and diversity of benthic species will be monitored at the sites described in Figure C-12 five times a year. Samples will be collected with a modified Surber sampler or an Ekmen grab. The samples will be washed in buckets with a U.S. Standard No. 30 sieve bottom and preserved with neutralized 10 percent formaline. Methods of laboratory analysis will be identical to those used during baseline, interim, and modular development monitoring.

Soils studies--Sampling of soils for trace elements will be done at two sites in the Tract C-a area. The locations of these sites are presented in Figure C-13. The two sampling sites are 2.4 x 2.4 km (1.5 x 1.5 miles). They represent the greatest impact and no impact areas. From these sites, 20 surface soil (0 to 10 cm or 0 to 4 in.) and 20 leaf samples will be collected annually for analysis in the laboratory. If significant amounts of the trace elements are detected in the source monitoring program, the soil and vegetation samples will be analyzed for As, B, Cd, F, Hg, Se, Mo, and V.

Measurements of soil conductivity may be carried out at two locations in the Tract C-a area (Figure C-13). These two sites (.8 sq km or 0.5 sq mi) should represent areas of maximum cooling tower salt drift impact and no impact. Twenty random samples will be collected annually during August. Methods of analysis will be conducted in the same manner as was done in the baseline, interim, and modular development phases.

Solid Waste Disposal, Revegetation

Baseline Data Gathering Program--

In 1975, a 3-year experimental revegetation program was initiated by RBOSP. The program included three successive plantings--two in 1975 and one in 1976. The first two plantings (1975) are included in the baseline environmental program and hence will be described here. The sources of information on these planting programs are References 1 and 18.

The revegetation plots initiated in 1975 are located in the north and south slopes of Wolf Ridge and are labelled R_1 and R_2 (Figure C-15). Sixteen treatments were applied at random to 10- x 10-m (33- x 33-ft) plots and replicated in three complete blocks. Since each plot was assigned a 3-m (10-ft) buffer zone, the total area of the site was 55 x 165 m or 9,075 m^2 (180 x 540 ft or 97,200 ft^2) bringing the

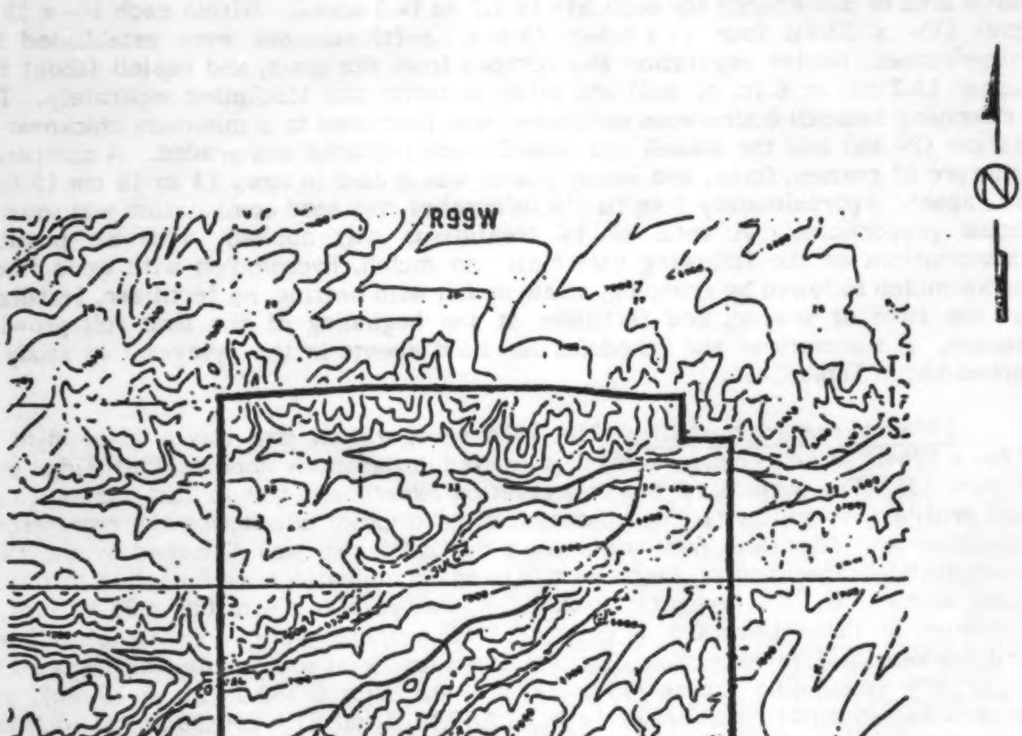
R99W
T
1
S
T
2
S
R1
R3
R2
0
½
1
Miles
N

Figure C-15. Location map for Tract C-a revegetation test plots for the baseline solid waste data-gathering program.

total area of disturbance for each site to 1.7 ha (4.3 acres). Within each 10- x 10-m plot (33- x 33-ft) four 1- x 0.5-m (3.2- x 1.6-ft) subplots were established for observation. Native vegetation was scraped from the plots, and topsoil (about the upper 15.2 cm or 6 in. of soil) and other material was stockpiled separately. The underlying bedrock (calcareous sandstone) was fractured to a minimum thickness of 61 cm (24 in.) and the subsoil and topsoil were replaced and graded. A composite mixture of grasses, forbs, and woody plants was drilled in rows 13 to 18 cm (5 to 7 in.) apart. Approximately 3 kg/ha (16 lb/acre) of this seed combination was sown in equal proportions. A total of 16 treatments was applied, with all possible combinations of the following variables: no mulch, hydromulch with wood fiber, straw mulch followed by crimping, straw mulch with netting, no fertilizer, fertilizer at the time of sowing, and fertilizer at the beginning of the first full growing season. A summary of the schedules for field events in the revegetation study is presented in Table C-14.

1976 revegetation studies--The 1976 revegetation site was a 53- x 53-m or 174- x 174-ft (0.3-ha or 0.70-acre) plot located in the south slope of Wolf Ridge (see Figure 15). The purpose of this revegetation experiment was to test the artificial soil profile that will cover the processed shale disposal pile during the commercial operation and disposal. Approximately 1 ha (2.5 acres) was disturbed by the 1976 revegetation experiments. Eighteen treatment combinations were applied to the 36 plots within the 1976 revegetation site. Within each 6 x 6 m (20 x 20 ft) plot, a minimum of three 1.0- x 0.5-m (3.2- x 1.6-ft) subplots were randomly established and marked for data collection. The simulated artificial soil profile was prepared by separately stockpiling topsoil (15.2 cm or 6 in.), subsoil (30.5 cm or 12 in.), and excavated sandstone (30.5 cm or 12 in.). An additional 91.4 cm (36 in.) of rock and soil material was excavated from the revegetation site and stockpiled. A plastic sheet was placed into a prepared area 1.7 m (5.5 ft) deep to reduce the possibility of contamination to groundwater and to facilitate collection of any leachate for analysis. Perforated plastic pipe was placed in three locations for collection of leachate: (1) at the top of the compacted shale; (2) beneath the compacted shale; (3) beneath the sandstone material on the control side of the experimental plot. Because of the limited availability of TOSCO II processed shale, 50.8 cm (20 in.) of processed shale was placed on top of the plastic sheet. The processed shale was compacted to prevent penetration or leaching and to simulate the 1.5 m (5 ft) surface layer of the compacted processed shale of the proposed disposal pile configuration. The control plot was underlaid by approximately 50. 8 cm (20 in.) of sandstone that had been excavated from the revegetation site and that had previously been stockpiled. After the processed shale was compacted, 1 m (3 ft) of overburden (30.5- x 0-cm or 12- x 0-in. size) was bulldozed over the processed shale and the excavated sandstone of the control plot. The topsoil and subsoil were replaced in proper sequence. Grass, forb, and shrub seed were sown as a composite at 2 cm (.8 in.) depth and 12.7- to 17.8-cm (5- to 7-in.) spacing. The eighteen treatments included three seeding intensities (low, ∼2.75 kg/ha or ∼15 lb/acre; medium, ∼3.67 kg/ha or 20 lb/acre; high, ∼4.59 kg/ha or 25 lb/acre) as well as three mulch and two shale and no shale substrates resulting in the following combinations:

TABLE C-14. SCHEDULE OF FIELD EVENTS FOR BASELINE REVEGETATION STUDIES ON OIL SHALE--TRACT C-a

Field event	1975[a]						1976												1977												1978											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Site Selection	▲																																									
Field work:																																										
Seedbed preparation				▲												▲												▲														
Planting				▲												▲												▲														
Measurements of plant response to treatments												▲		▲										▲		▲										▲		▲				
Soil analyses:																																										
Sample collections				▲												▲												▲														
Moisture determinations					▲							▲		▲		▲								▲		▲		▲								▲		▲		▲		
Salinity determinations																▲												▲												▲		

[a] Months of the year are indicated, in order, by their first initial.

Substrate	Seeding intensity	Mulch
Shale	Low	None
Shale	Medium	None
Shale	High	None
Shale	Low	Hydromulch
Shale	Medium	Hydromulch
Shale	High	Hydromulch
Shale	Low	Straw
Shale	Medium	Straw
Shale	High	Straw
No shale	Low	None
No shale	Medium	None
No shale	High	None
No shale	Low	Hydromulch
No shale	Medium	Hydromulch
No shale	High	Hydromulch
No shale	Low	Straw
No shale	Medium	Straw
No shale	High	Straw

The following plant response parameters will be measured for each treatment: (1) number of emerged seedlings per lot; (2) number of surviving seedlings per plot; (3) percent cover. Additional information concerning the experiments initiated in 1976 is presented in the RBOSP Progress Report 9 (19), and the 1976 and 1977 Annual Revegetation Reports (18).

Tubelings are being grown by the USDA Shrub Science Laboratory from the same seed lots that were used for direct seeding. Five shrub species (excluding *Amelanchier alnifolia*) and pinyon pine will be utilized for the tubeling treatment. Tubeling size will be 294 cm^3 or 5.1 x 3.8 x 15.2 cm (18 $in.^3$ or 2 x 1.5 x 6 in.). The tubelings were planted by hand in each treatment plot (R_3) in early or mid-June at a rate of 18 tubelings/plot (728 tubeling/ha or 1,800 tubelings/acre); three tubelings of each of the six species was used.

Monitoring Programs for the Interim and Modular Development Phases--

During construction in the modular development phase, approximately 63 ha (155 acres) were disturbed (1977-78), 24 ha (60 acres) of which have been revegetated. A summary of the seeding and mulching activities is presented in Tables C-15 and C-16.

In addition, 1979 marked the last year of the RBOSC 3-year experimental revegetation program. Percent cover and biomass were measured at Sites R_1 and R_2 (Figure C-15) during the third growing season in 1978. Percent cover was estimated by visual estimates, and biomass by harvesting. An analysis of variance was performed to determine if significant differences existed between mulch, fertilizer treatments, and plant species. Percent cover, height, and diameter of shrub seedlings were also measured during the third growing season of 1978 at Site R_3. An analysis of variance was also performed at R_3.

TABLE C-15. SUMMARY OF SEEDING AND MULCHING ACTIVITIES PERFORMED DURING REVEGETATION IN 1978 AT TRACT C-a

Disturbed area	Seeding mixture	Seeding method	Hydro-mulched	Seeding rate (lb PLS/acre)[a]
Access road berms	1	H	x	38
Water reinjection	1	H	x	38
West settling basin	2	D		16
Ore disposal area	2	D		16
Soil storage	2	D		16
Plant site/mine service area				
Blowdown/retention ponds	2	H	x	32
Plant side slopes	3	H		50
Area near hunting club	1	D	x	19
Area between water tank and plant site	1	D	x	19
Diversion system	2	H,B		32
Equipment yard	1	D		19
Reservoirs/soil piles				
Hunting Road clay pit	2	D		16
Meteorological Site 4	1	D		19

[a] H - Hydroseed
D - Drill
B - Broadcast
PLS - Pure live seed

TABLE C-16. THREE SEED MIXTURES USED FOR RBOSC REVEGETATION ACTIVITIES DURING FALL 1978

Seed mixture	Plant species	Seeding rate Approximate (lb PLS/acre)[b]
1 - Permanent	Luna pubescent wheatgrass	2.5
	Western wheatgrass	3.5
	Sodar streamband wheatgrass	2.0
	Indian ricegrass	1.5
	Green needlegrass	1.5
	Manchar brome	1.5
	Cicer milkvetch	1.5
	Madrid yellow sweetclover	0.75
	Lewis flax	1.0
	Winterfat	1.0
	Fourwing saltbush	1.0
	Bitterbrush[c]	1.0
Total		18.75
2 - Temporary	Yellow sweetclover	1.0
	Barley	1.0
	Western wheatgrass	6.0
	Luna pubescent wheatgrass	8.0
Total		16.0
3 - Temporary	Yellow sweetclover	4.0
	Crested wheatgrass	8.0
	Barley	8.0
	Luna pubescent wheatgrass	5.0
Total		25.0

[a] Based on drilling rate; rate for broadcasting is doubled.

[b] PLS - pure live seed.

[c] Bitterbrush was included in seed mixture for Airplane Ridge Road and areas near the Hunting Club.

Soil moisture measurements were also made at R_1, R_2, and R_3 during June, August, and October 1978. Soil conductivity was measured at 0-, 25-, and 50-cm (0-, 9.8-, and 19.7 in.) depths at R_3.

Proposed Commercial Development Phase Monitoring Program--

Data gathering during the baseline, interim, and modular development phase revegetation program will determine which agricultural practices are the most appropriate for revegetating disturbed soil in the Tract C-a area. The practices to be determined include those relating to seedbed preparation, seeding, use of mulches and fertilizer, irrigation, biotic influences and interaction, and management. At the conclusion of modular development revegetation monitoring, the most appropriate methods of utilizing the above-mentioned agricultural practices will be determined and employed in the revegetation of shale disposal piles.

All revegetation will take place 1 year after land disturbance. Revegetation of raw shale will be delayed until disposal is completed. Revegetation of processed shale will take place in sections as the shale is disposed of. In small-surface disturbed areas a mixture of grasses and forbs will be seeded. In larger disposal areas, a mixture of grasses, forbs, and shrubs will be seeded to provide for more rapid introduction of browse and forage for domestic and wildlife species.

A sampling program will be conducted on revegetated soils to determine the success of growth, range productivity, browse utilization, species composition, soil properties, small mammals abundance, and avifauna. The program will take place during the first five growing seasons after seeding. The parameters, sampling techniques, sampling frequency, and sampling intensity to be used are summarized in Table C-17.

Noise

Baseline Data Gathering Program--

There have been two studies of ambient noise levels that can be considered part of the baseline data gathering program at Tract C-a. The first program took place during the period of August through December 1975. The data from this program have been reported previously in the RBOSP DDP in 1976 (11). During the summer of 1976, a second 3-day study was conducted. This program has been outlined in the Final Environmental Baseline Report (1). Sound levels were measured and recorded at the four air quality monitoring sites with a frequency of once every 20 min during the four divisions of the day--morning (0700 - 1200), afternoon (1200 - 1800), evening (1800 -2200), and night (2200 - 0700). The tape recordings were analyzed at a later date. Data were not used if the wind speed was greater than 6 m/sec (19.7 ft/sec), and wind pops and aircraft overflight were edited from the tape. Data were not recorded when the wind speed or relative humidity was high (more than 90 percent relative humidity) at the beginning of a 20-min period. Computations were made to determine the cumulative frequency of occurrence of specific noise levels: the noise level exceeded 95 percent of the time, the noise level exceeded 5 percent of the time, the integrated 24-hr average, the constant noise equivalent of the integrated noise recording, and the A-weighted noise intensity. (The A-weighted measurement represents that which would be perceived by the human ear, as opposed to the absolute pressure of the sound waves, represented by the other measures.)

TABLE C-17. COMMERCIAL DEVELOPMENT PHASE SOLID WASTE MONITORING PROGRAM AT TRACT C-a

Sampling program	Parameter	Sampling frequency	Sampling techniques	Sampling intensity	Data analyses
Vegetation	Species composition	Before revegetation, Year 3, 5...	Quadrat (9.6 ft^2) 0.89 m^2	1 Transect/40 ha (100 acres) (10 quadrats each - 10 m intervals)	Coefficient of community Percent similarity Pielou (20)
	Percent cover	Before revegetation, Year 3, 5...	Quadrat (9.6 ft^2) 0.89 m^2	1 Transect/40 ha (100 acres) (10 quadrats each - 10 m intervals)	Coefficient community Percent similarity Pielou (20)
	Productivity & utilization	Before revegetation, Year 3, 5...	Double sampling method (USDA, 1970)	1 Transect/40 ha (100 acres) (10 plots each)	Analysis of variance Multiple range test
	Browse condition & utilization	Before revegetation, Year 3, 5...	Cole (12)	1 Transect/40 ha (100 acres) (25 individual)	Analysis of variance Multiple range test
Soils	pH Macronutrients (N, P, K) Micronutrients (Cl, Ca, Na)	Year 1, 3, 5...	Soil cores - (0-10 cm; 30-40 cm)	1 Sample/40 ha (100 acres)	Qualitative Analysis of variance Multiple range test
	Conductivity Trace elements (Ar, B, Zn, Se, etc.)	Year 1, 3, 5...	Soil cores - (0-10 cm; 30-40 cm)	1 Sample/40 ha (100 acres)	Analysis of variance Multiple range test
Fauna	Small mammals Species composition Index of abundance	Before revegetation, Year 1, 3, 5...	Pit trapping Live trapping	5 Transects/unit (2 transects of 10 traps/group)[a]	Regression analysis; F-test; Analysis of variance (index of abundance)
	Avifauna Species composition Map of territories Density of breeding Birds	Before revegetation, Year 1, 3, 5...	Breeding bird mapping technique Graul (15); Hall (16); Robbins (17)	12-45 ha (30-105 acres) (depending on size of area) Divided into 1-ha subunits; 8 replicates of subunits[a]	Regression analysis, Analysis of variance (for density only)

[a] Adequate sample size will be determined during the first year.

Interim Monitoring Program--

Noise levels were not expected to change from the baseline period to the modular development period, and hence this parameter was not measured during the interim monitoring program.

Modular Development Phase Monitoring Program--

Noise measurements are being made at 16 locations on a quarterly basis. These locations represent a series of concentric circles from the construction area out to the borders of Tract C-a (Figure C-16). Each permanent site will be flagged and visited once each quarter. In addition to these quarterly measurements, opportunistic readings will be taken in construction or mining areas and at several selected off-tract locations during peak levels of activity to determine the sources and levels of noise and the distances at which the sounds can be heard.

Sound level readings will be taken with a Bruel and Kjaer Sound Level Meter, Type 2205. The accurate range of this instrument is 20 to 130 decibels. A Condenser Type 1, ANSI S1.12 omnidirectional microphone will be used to receive noise impulses. The sound level meter will be calibrated as necessary with a Bruel and Kjaer Sound Level Calibrator, Type 4230, operating on a frequency of 1000 Hz ± 1 percent. Wind speed will be determined with a Taylor Instrument Company, handheld anemometer. Wind direction will be estimated with the aid of a compass.

The sound level meter will be calibrated using the Sound Level Calibrator before each survey. Wind speed (mph), wind direction (degrees), and time will be recorded at the start of each survey. Highest and lowest values on the meter during a 20-sec period will be recorded for each site. Measurements will be repeated five times. Comments noting unusual circumstances (i.e. jet overhead) and general conditions during the reading will be recorded.

Sound level readings will be reported as highest and lowest range for each of the five readings at each site and as the sound level average of all five sites. Averages will be determined by adding all 10 values for each site and dividing by 10. Values will be reported in decibels, A weighting (dBA).

Commercial Development Phase Monitoring Program--

During the commercial development phase at Tract C-a, noise will be monitored. The program outline is presented in the revised DDP (11). Again it should be noted here that this monitoring program may be changed.

During commercial operation, noise levels will be monitored in both the working areas and in the project's surrounding environment. Ambient noise levels to which workers might be exposed will be performed semiannually, or when significantly different noise sources are installed or put into operation. These surveys will be made in accordance with American National Standards Institute Standard SI-41971. Semiannual measurements will be made of the ambient noise levels around the project until a constant level of activity is achieved. At that time, the program will be geared completely toward occupational safety.

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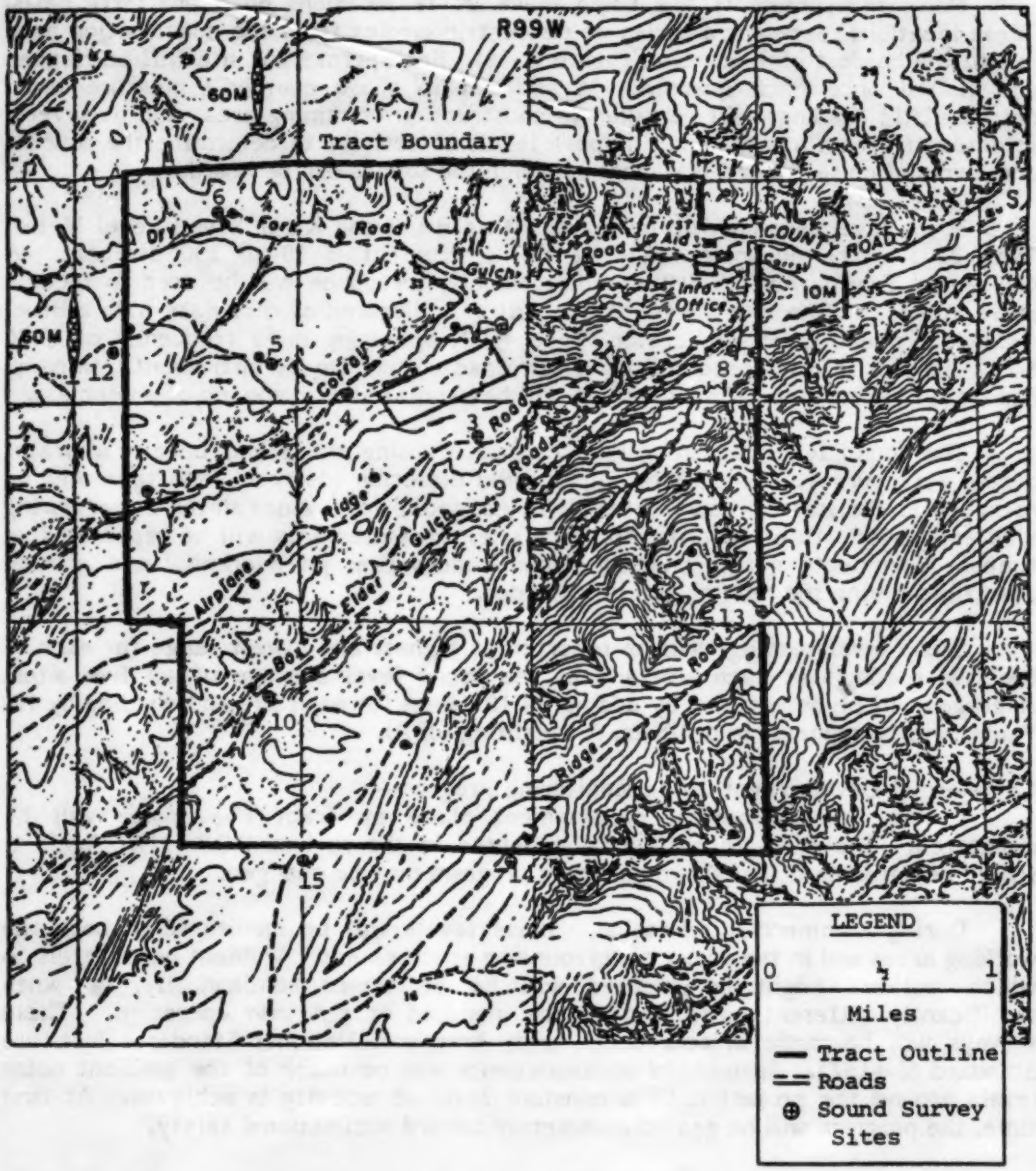

R99W
60M
Tract Boundary
T 1 S
6
Dry Fork Road
Gulch
Road
First Aid
COUNTY ROAD
Info. Office
10M
60M
5
12
Corral
8
4
3
Road
Road
11
9
Ridge
Gulch
Airplane
Bol
Elder
13
Road
10
Ridge
T 2 S
15
14
LEGEND
0
½
1
Miles
Tract Outline
Roads
Sound Survey Sites

Figure C-16. Environmental sound-level monitoring sites, RBOSC Tract C-a.

Radioactivity

Baseline Data Gathering Program--

During the baseline data gathering program at Tract C-a, radioactivity was measured in soil profiles, processed shale, surface water, and groundwater. The documents from which information was gathered for this report include References 1, 2, and 21.

Processed shale was analyzed at one time for uranium, equivalent uranium, equivalent thorium, potassium, and radium-226. The local soil series were also analyzed for the above-mentioned radioactive constituents.

In addition, the surface water and groundwater were both analyzed for gross alpha and gross beta. The frequency with which these parameters were measured is outlined in the baseline water resources monitoring program (see subsections on surface water and groundwater under Tract C-a, Water Resources).

Interim Monitoring Program--

Radioactivity was not measured during the interim monitoring period in either the water or the ambient air.

Modular Development Phase Monitoring Program--

During the modular development phase, radiation was monitored at Tract C-a only in the surface and groundwater. The main sources of information relating to this monitoring program are the Modular Development Phase Monitoring Reports One, Two (6 and 7), and the Tract C-a Supplement to the DDP (8).

Water from surface streams, alluvial aquifers, and deep oil shale aquifers were monitored semiannually for the following: Gross alpha (if >4 pCi/l then Ra^{226} or >15 pCi/gal, natural uranium), gross beta (if >100 pCi/l or >379 pCi/gal, then Sr^{90}, Ce^{137}).

Proposed Commercial Development Phase Monitoring--

It is proposed that radioactivity be measured during the commercial phase development monitoring program. The program description has been outlined in the Revised DDP (11). This monitoring program may change.

Radiation will be analyzed in the surface water, alluvial water, and deep oil shale aquifer water quality analyses. The monitoring stations are located in the same positions described under Tract C-a Water Resources in the Subsection Proposed Commerical Operations Water Monitoring Schedule. Gross alpha, natural uranium, and gross beta measurements will be taken semiannually in surface and alluvial aquifer waters. The same parameters will be measured in the deep oil shale aquifers on a monthly basis at the outset and semiannually after consistent measurements are found.

Surface Subsidence

Baseline Data Gathering Program--

No ground subsidence measurements were made during the baseline data gathering program.

Interim Monitoring Program--

No ground subsidence measurements were made during the interim monitoring program.

Modular Development and Commercial Development Phase Monitoring Program--

During the modular development phase, a surface subsidence monitoring program was initiated to study the subsidence over the modular development burn area. The main source of information on this subject is the Supplement to the Revised DDP (22). A surface subsidence monitoring program will be performed during commercial development also. The source of information on this subject is the Revised DDP (11).

During the modular development phase, 30 monuments were placed in 1978 above planned retorts, and other areas were expected to experience subsidence. The monuments were constructed of steel-reinforced bars up to 25.4 cm (10 in.) long, driven to the ground past soil horizons and into bedrock shale. A benchmark was established at a sufficient distance from the retort area to assure that it would not be affected. Subsidence monitoring ensued in March 1978.

Subsidence in the ground surface over the modular development phase retort area will be monitored during and after completion of the burn. The horizontal and vertical relationships of these monuments to an unaffected benchmark will be determined. During and after the burn, the position of the monuments will be recorded periodically. If any significant change takes place, the altered topography will be mapped. The behavior of these modular development phase retorts after the burn will be observed to serve as an indicator of what can be expected from the commercial phase retorts. The top of some of the modular development phase retorts will be reentered, if possible, to quantify shrinkage of the rubble zone. Because subsidence tends to be a long-term effect, subsurface monitoring of the rock integrity above the most subsidence-prone retorts will be performed. This will be done either by borehole instruments, access drifts, or seismic methods. The behavior of the retort roof after the burn will be observed by the methods found to be the most effective.

The monitoring of subsidence over the commercial phase retorts will consist solely of the placement of a monument or a monument grid over each retort to record vertical and horizontal displacements at appropriate intervals. This practice may be discontinued if no subsidence takes place or if mitigative measures prove to be uniformly successful.

TRACT C-b

Air Resources

Baseline Data Gathering Program--

The Tract C-b baseline study was performed from November 1974 to November 1976. The published documents that have been used as reference in the preparation of this report are the Tract C-b First Year Environmental Baseline Program: Annual Summary Report (23) and the Final Environmental Baseline Program Report (24).

Five sampling stations were established during the baseline program to monitor ambient air quality around Tract C-b. The meteorological monitoring network consists of three mechanical weather stations, a 60-m (200-ft) meteorological tower, two acoustic sounders, and one location for measuring areawide visibility. The locations of these sampling sites are presented in Figure C-17.

The air quality and meteorological parameters measured and the frequency of sampling at each monitoring site are presented in Table C-18.

Sulfur dioxide, hydrogen sulfide, and suspended particulates were measured at all air quality stations. Hydrocarbons, methane, nitrogen oxides, ozone, and carbon monoxide were measured at two stations. Each of the sampling sites were equipped with four high-volume samplers for the monitoring of suspended particulates. The samplers were situated approximately (4.6 m or 15 ft) above ground level and geared to take samples for 24 hr every day. In addition, particulates were analyzed on a quarterly basis for alpha and beta radioactivity and trace metals.

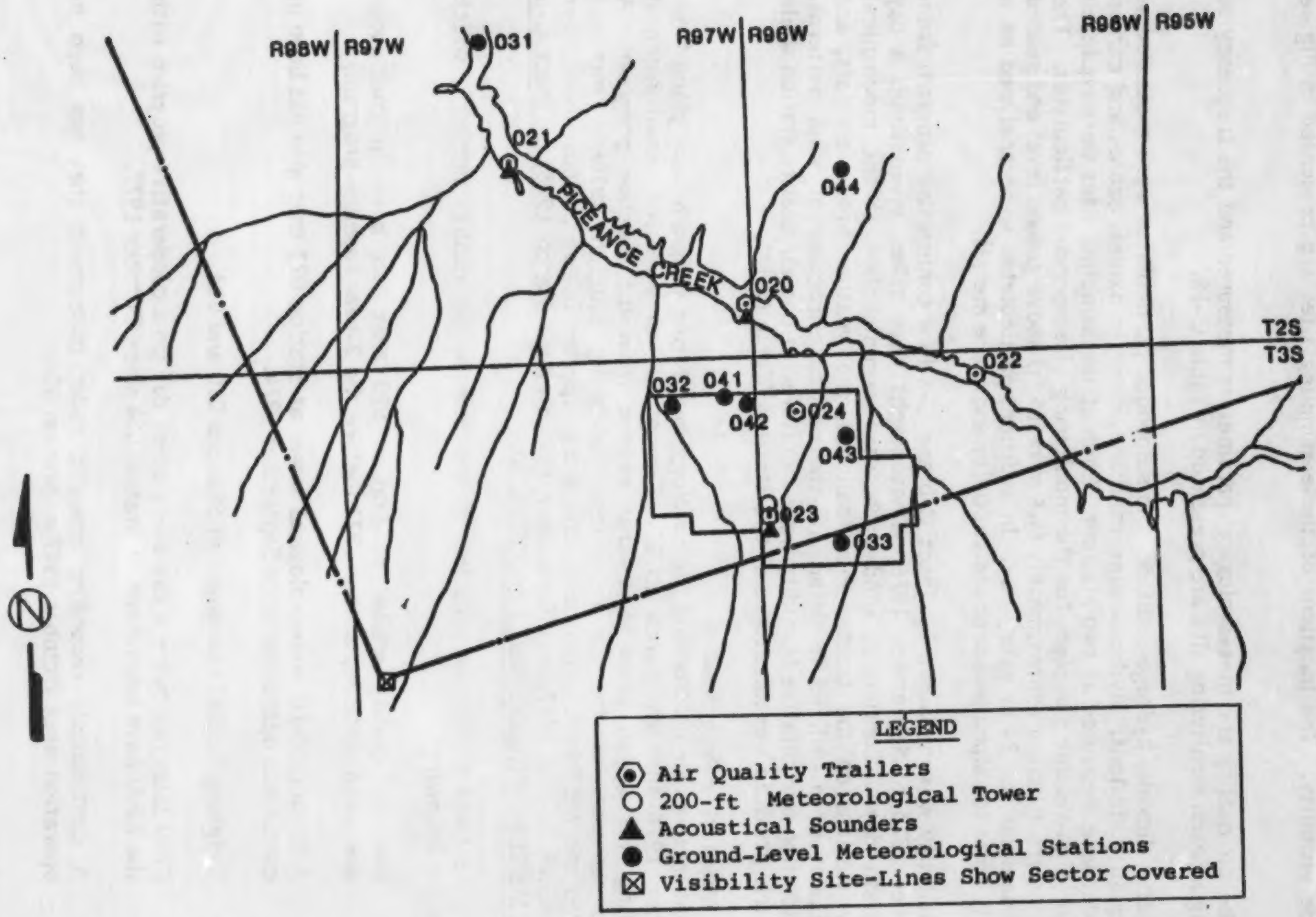
Visibility was measured by Tract C-b and C-a in a conjunctive program from September 1975 to September 1976. Photographs were taken seven times a day every sixth day. Continuous wind data were accomplished at the mechanical weather stations on the tract. Pibal balloons, the weather tower, aircraft, and tethersondes were utilized to determine the vertical structure of wind patterns. Solar radiation and relative humidity were monitored at one air quality station while barometric pressure was monitored at two stations (Table C-18).

Interim Monitoring Program--

The interim air quality and meteorology monitoring program took place from November 1976 through March 1978. During this time period, environmental monitoring was scaled down to a large degree from the baseline program. A detailed summary of the air resources monitoring program criteria was not submitted and published. Monitoring data were reported in two periods: November 1976 through August 1977, and September 1977 through March 1978, in Tract C-b Interim Monitoring Report Nos. 1 and 2 (25,26).

Figure C-18 shows the location of the interim air quality network, which includes the following:

- One air quality trailer at Station 023 that has been in continuous operation since September 1974 (before the 2-year baseline program)
- A 60-m (200-ft) meteorological tower at Station 023 that also has been in continuous operation since September 1974.
- Weighing-bucket rain gages at Stations 020 and 023
- Pibal launches twice a day every other day (in a cooperative program with the EPA) have been made at Station 024 since October 1977.
- A continuously recording acoustic radar instrument that has been in operation since October 1977 at Station 020.


R98W
R97W
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R96W
R96W
R95W
T2S
T3S
031
021
020
022
032
041
042
024
043
044
023
033
PICEANCE CREEK
LEGEND
Air Quality Trailers
200-ft Meteorological Tower
Acoustical Sounders
Ground-Level Meteorological Stations
Visibility Site-Lines Show Sector Covered

Figure C-17. Baseline air quality and meteorological monitoring network at Tract C-b.

TABLE C-18. SUMMARY OF BASELINE AIR QUALITY AND METEOROLOGY MONITORING PROGRAM AT TRACT C-b

Air quality and meteorology parameters	Baseline monitoring program[a]												Sampling instrumentation
	Air quality station								Meteorological tower				
	020	021	022	023	024	1	2	3	8 ft	10 ft	100 ft	200 ft	
SO_2	X	X	X	X	X								Meloy Model SA185-2 (flame photometric)
H_2S	X	X	X	X	X								Meloy Model SA185-2 (flame photometric)
Particulates	O	O	O	O	O								High volume samplers
THC	4			4									Bendix Model 8200 (gas chromatograph)
CH_4	4			4									Bendix Model 8200 (gas chromatograph)
NMHC	X			X									
O_3	X			X									Meloy Model OA 350 (chemiluminescent)
NO	X			X									Meloy Model NA 520 (chemiluminescent)
NO_x	X			X									Meloy Model NA 520 (chemiluminescent)
NO_2	X			X									Meloy Model NA 520 (chemiluminescent)
CO	X			X									Bendix Model 8200 (gas chromatograph)
Horizontal wind speed	X	X	X	X	X	2	2	2	X	X	X	X	Weather Measure 103/3 and -04-2
Horizontal wind direction	X	X	X	X	X	2	2	2	X	X	X	X	Meteorology Research Inc. 1674-2
Bivance wind speed										X	X	X	Model 21002 Gil Anemometer Vane
Bivance horizontal wind direction										X	X	X	Model 21002 Gill Anamometer Vane
Bivance vertical wind direction										X	X	X	Texas Instruments Model 2013
Relative humidity	X	X	X	X	X				X	X	X	X	Texas Instruments Model 2013
Air temperature	X	X	X	X	X	2	2	2	X	X	X	X	Weather Measure Model 7621-TP18X
precipitation	X	X	X	X	X								Weather Measure Model P511-E
Barometric pressure				X	X								Weather Measure B242 Barometer
Solar radiation				X									MRI Model 840
Temperature difference											1		
Acoustic echo													
Visibility													

[a] Legend:
X = Sampled every 10 sec.
4 = Sampled every 5 min.
0 = Sampled every third day
2 = Sampled continuously
1 = Standard deviation calculated

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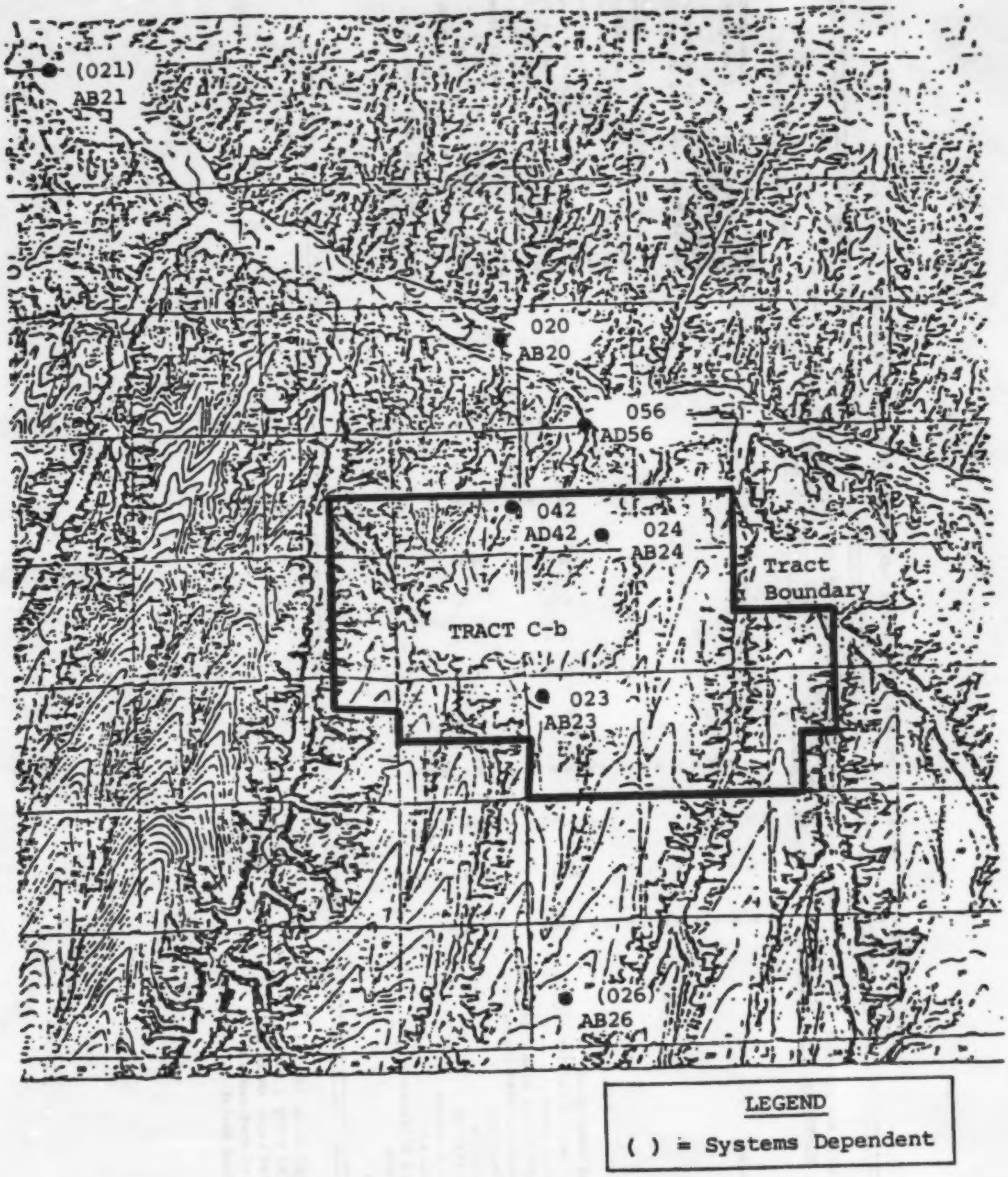
(021)
AB21
020
AB20
056
AD56
042
AD42
024
AB24
Tract
Boundary
TRACT C-b
023
AB23
(026)
AB26
LEGEND
( ) = Systems Dependent

Figure C-18. Ambient air quality interim and development monitoring network at Tract C-b.

- Mechanical weather stations coupled with hi-vol particulate samplers that have been in operation since February 1978 at Stations 042 and 056.

Development Phase Monitoring Program—

The development phase monitoring program to be discussed here covers the time period from February 1978 through commercial development. The sources of information for this report were References 20, 27-29.

Gaseous Pollutants and Particles—

There have been five air quality and meteorology monitoring stations set up around Tract C-b. As of February 1978, two of the five stations (Stations 020 and 023) are sampling for air quality analyses. The locations of all air quality sampling stations developed for the development monitoring program are presented in Figure C-18. The sampling schedule and parameters being measured as part of the developmental phase monitoring program are presented in Table C-19. Air quality parameters are measured at two stations (020, 023). Monitoring at Station 024 is to begin in 1980. Particulates are measured at five stations, three on the tract and two off. Baseline station 021 and 022 are discontinued. Minimum data reporting frequencies consist of 1-hr averages. One-, 3-, 8-, and 24-hr averages will continue to be computed as necessary for comparison with standards.

During operation of the development phase retorts, stack emissions monitoring will be carried out as part of the PSD permit requirements. An outline of this emission source monitoring program at Tract C-b is presented in Table C-20.

Visibility—Area-wide visibility is measured from one vantage point at Hunter Creek. Four views are obtained by camera seven times a day, every sixth day for 10 days in spring and 10 days in fall. Hourly maximum and minimum visual ranges, and means and standard deviation by variable are calculated.

Meteorology--Air temperature, relative humidity, barometric pressure, solar radiation, evaporation, precipitation, horizontal wind speed (10 m, 30 m, 60 m or 33 ft, 100 ft, 200 ft), horizontal wind direction (10 m, 30 m, 60 m or 33 ft, 100 ft, 200 ft), vertical wind speed, Δ temperature (10 m, 60 m or 33 ft, 200 ft) mixing layer height and winds aloft are all measured as part of the development meteorology monitoring program. Station 023 is the most heavily instrumented trailer utilizing a 60-m (200-ft) meteorological tower and containing all tower data channels. The schedule for this program beginning in February 1978 is illustrated in Table C-20.

Proposed Commercial Development Monitoring Program—

As part of the commercial development at Tract C-b, monitoring of ambient air quality and meteorology will continue along much the same line as has been outlined for the developmental phase. In addition to ambient monitoring and as part of the commercial development monitoring program, emission source monitoring will also be conducted to be in compliance with PSD regulations.

The emission source monitoring program that has been developed for Tract C-b is summarized in Table C-20. In addition, air diffusion modeling will be validated after the onset of commercial operation. Tracers will be utilized to allow for easier ground concentration measurement.

TABLE C-19. SUMMARY OF DEVELOPMENT PHASE AIR QUALITY AND METEOROLOGY MONITORING PROGRAM AT TRACT C-b[a]

Sampling station		Monitoring date	SO_2	H_2S	Particulates[b]	NO_x	NO	NO_2 (1)	CO	Horizontal wind speed	Horizontal wind direction	Vertical wind speed[c]
Air-quality trailer:												
020		a) Jan. '78			0					X	X	
		b) July '78				X	X	X	X			
		c) 1980	X	X								
021		Systems-dependent										
023		Nov. '74	X	X	0	X	X	X	X			
024		a) 1980			0					X	X	
		b) 1981	X	X								
026		Systems-dependent										
Weather station & hi-vol sampler:												
042		Feb. '78			0					Z	Z	
056		Feb. '78			0					Z	Z	
Met. Tower @												
3 m		Nov. '74										
10 m		Nov. '74								X	X	X
30 m		Nov. '74								X	X	
60 m		Nov. '74								X	X	X
Upper air studies:												
Minisonde		Oct. '77								W	W	
Acous. sound,	020	Oct. '77										
Visibility, station	060	Apr. '78										
Tracer studies		Fall '78										

---

[a] Legend:

X = Sampled every 10 s
Y = Sampled every 5 min.
Z = Sampled continuously
0 = Sampled every third day
2 = Sampled every 10 s
W = Sampled every 30 s
U = Sampled every 14 s
V = Sampled seven times per day every sixth day for 20 days in spring and fall
T = Sampled continuously for 2 days
S = Sampled weekly

[b] Also size distributions during visibility study.

[c] Std. deviation calculated.

[d] These stations also used to obtain water quality of ppt. measurements.

* @ 1 m

(1) $(NO_2) = (NO_x) - (NO)$

(continued)

TABLE C-19. (continued)

Sampling station	[a]	Monitoring date	Relative humidity	Air temperature	Precipitation[d]	Evaporation	Barometric pressure	Solar radiation	Temperature difference	Mixing height	Visible range	Height	SF_6
Air-quality trailer:													
020		a) Jan. '78			Z								
		b) July '78		X									
		c) 1980											
021		Systems-dependent											
023		Nov. '74			Z	S	X	X					
024		a) 1980		X									
		b) 1981											
026		Systems-dependent											
Weather station & hi-vol sampler:													
042		Feb. '78		Z									
056		Feb. '78		Z									
Met. Tower @													
3 m		Nov. '74	X[e]										
10 m		Nov. '74		X					2				
30 m		Nov. '74		X									
60 m		Nov. '74		X					2				
Upper air studies:													
Minisonde		Oct. '77		W								W	
Acous. sound,	020	Oct. '77								U		U	
Visibility, station	060	Apr. '78									V		
Tracer studies		Fall '78											T

[a] Legend:
X = Sampled every 10 s
Y = Sampled every 5 min.
Z = Sampled continuously
O = Sampled every third day
2 = Sampled every 10 s
W = Sampled every 30 s
U = Sampled every 14 s
V = Sampled seven times per day every sixth day for 20 days in spring and fall
T = Sampled continuously for 2 days
S = Sampled weekly

[b] Also size distributions during visibility study.

[c] Std. deviation calculated.

[d] These stations also used to obtain water quality of ppt. measurements.

[e] @ 1 m

(1) $(NO_2) = (NO_x) - (NO)$

TABLE C-20. DEVELOPMENT PHASE EMISSION MONITORING AT TRACT C-b

(Under EPA PSD Permit)

	Type of emission														
Type of stack	Arsine	SO_2	H_2S	Particulate	CS_2	COS	Mercaptan	NO_x	O_2	CO_2	CO	Flow Rate	Temp	Moisture	Opacity
Thermal oxidizer		X		X											X
Stretford in		X	X		X	X	X					X	X	X	
Stretford out		X	X		X	X	X					X	X	X	
Mine vent		X		X											X
Mine shaft transfer				X											X
Shale conveyor				X											X
ROM ore handling				X											X
Steam boiler		X		X				X	X	X	X				X

Water Resources

Baseline Data Gathering Program--

Surface water gaging stations were constructed at 13 locations on or near Tract C-b through a contract arrangement with the USGS and the Colorado River Water Survey and the Colorado River Water Conservation District. The locations of these stations are shown on Figure C-19. Under this contract, the USGS Water Resources Division Sub-District office in Meeker was responsible for operation and maintenance of these stations.

Four of the 13 stations were located on perennial streams, and consequently, sampling on these streams could be carried out on a uniform frequency. Sampling on the remaining nine streams was opportunistic, however, and could only be done during periods of stream flow. The surface water gaging stations are maintained and operated continuously, either automatically or manually. A site log is kept at each station to assure accurate sampling records.

Water quality--

Initially, water quality samples were obtained and analyzed every 2 weeks. After the first year's baseline data were gathered and analyzed, the frequency of sampling was changed to monthly, except for the analysis of trace elements and insecticides, which was conducted quarterly (Table C-21).

Depth integrating samplers are used to collect water samples for analyses of nonvolatile constituents and those unaffected by aeration. Some samples are filtered through a 0.45-µm filter to remove turbidity. From the untreated filtrate, the following determinations are made:

- Boron
- Chloride
- Fluoride
- Hardness
- Lithium
- Nitrogen nitrate
- Nitrogen nitrite
- Phosphorous
- Potassium
- Selenium
- Silica
- Sodium
- Solids (dissolved)
- Sulfate

A second sample was filtered and acidified in the field with double-distilled, reagent-grade nitric acid (HNO_3) to obtain a pH of 3.0. The following determinations were then made:

- Aluminum
- Arsenic
- Barium
- Cadmium
- Calcium
- Chromium
- Manganese
- Molybdenum
- Nickel
- Potassium
- Silver
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Magnesium
- Sodium
- Strontium
- Vanadium
- Zinc

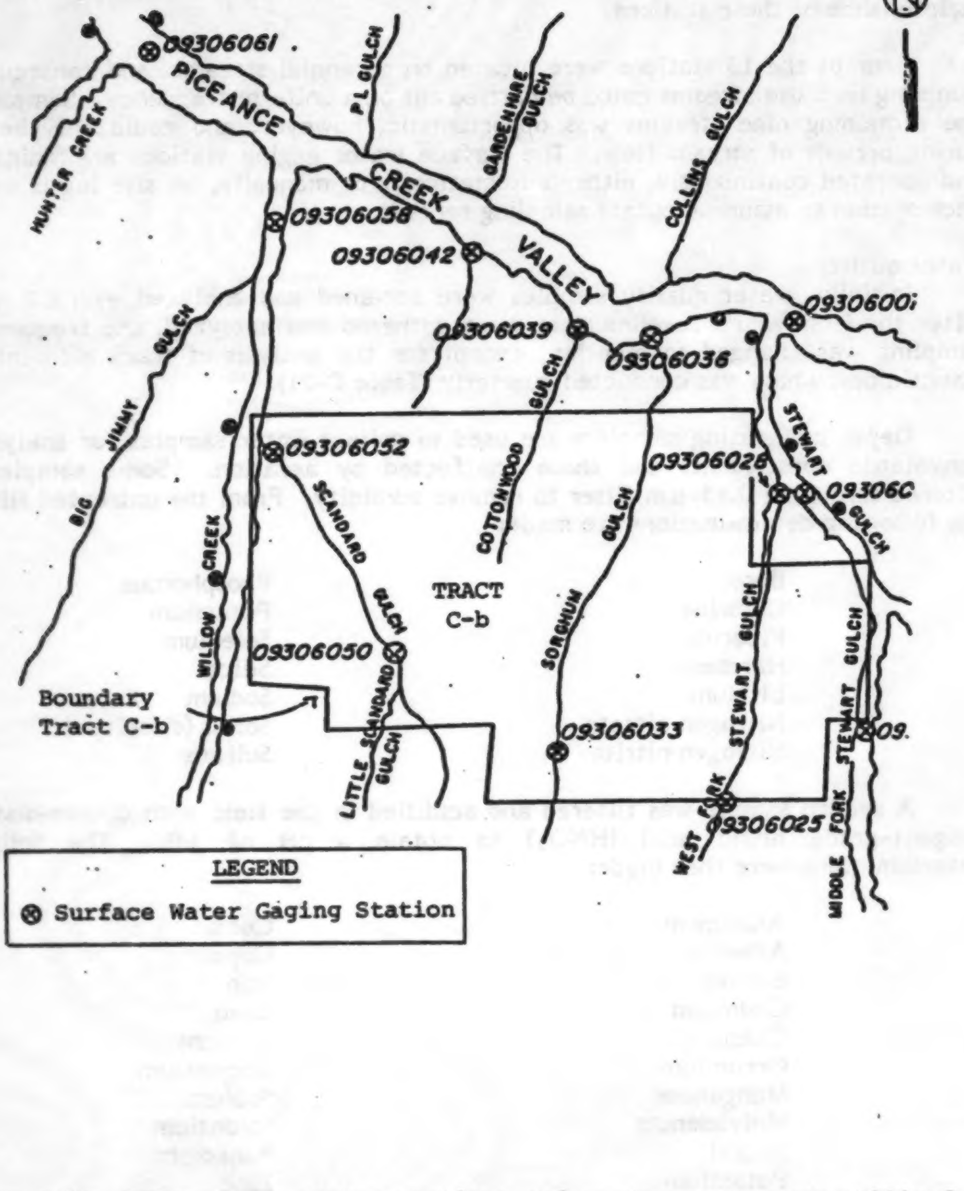
09306061
PICEANCE
CREEK
VALLEY
HUNTER CREEK
P L GULCH
GARDENHIRE GULCH
COLLINS GULCH
09306058
09306042
0930600
09306039
09306036
BIG JIMMY GULCH
09306052
SCANDARD
COTTONWOOD GULCH
09306026
09306C
STEWART GULCH
WILLOW CREEK
TRACT C-b
09306050
LITTLE SCANDARD GULCH
SORGHUM GULCH
Boundary Tract C-b
09306033
WEST FORK STEWART GULCH
MIDDLE FORK STEWART GULCH
09.
09306025
LEGEND
⊗ Surface Water Gaging Station

Figure C-19. USGS stream gaging stations and springs and seeps utilized during surface-water monitoring program at Tract C-b.

TABLE C-21. SUMMARY OF SURFACE WATER AND GROUNDWATER SAMPLING SCHEDULE AT TRACT C-b

Parameter	Baseline data gathering program			Development monitoring program		
	Surface water	Springs & seeps	Groundwater	Surface water	Springs & seeps	Groundwater
Aluminum		V	SA	Q (Z)	Q (A)	Q (Al), SA (Aq)
Alkalinity				M (Z)	Q (A)	Q (Al), SA (Aq)
Ammonia	S	V	SA	Q (Z)	M	Q (Al), SA (Aq)
Aromatics, Polycyclic	Q (Z)				Q (A)	
Arsenic	S	V	SA	Q (Z)	Q (A)	Q (Al), SA (Aq)
Barium	S	V	SA	Q (Z)	Q (A)	Q (Al), SA (Aq)
Beryllium		V	SA			A (Al)
Bicarbonate	S	V		M (Z)		
BOD				Q (Z)	Q (A)	SA (Al), SA (Aq)
Boron	S	V	SA		Q (A)	Q (Al), SA (Aq)
Bromine		V	SA		A	A (Al), SA (Aq)
Cadmium	S	V	SA	Q (Z)	Q (A)	Q (Al)
Calcium	S	V	SA	M (Z)	Q (A)	Q (Al), SA (Aq)
Carbonate	S	V	SA	M (Z)	Q (A)	Q (Al), SA (Aq)
Chloride	S	V	SA	M (Z)	Q	Q (Al), SA (Aq)
Chromium	S	V	SA		Q (A)	Q (Al), SA (Aq)
Cobalt		V	SA	Q (Z)		SA (Aq)
Color	S					
COD	Q (Z)				Q (A)	Q (Al), SA (Aq)
Coliform, Total + Fecal	Q (Z)			Q (Z)	S	
Conductivity, Specific	C (Z), X (O)	V	SA	Q (Z)	M (A)	Q (Al)
Copper	S	V	SA	Q (Z)	Q (A)	Q (Al), SA (Aq)
Cyanide	S	V		Q (Z)		
Dissolved oxygen	S, C (Z)				M	M (Al),
Fluoride	S	V	SA		Q (A)	Q (Al), SA (Aq)
Hardness					Q (A)	Q (Al), SA (Aq)
Iron	S	V	SA	M (Z)	Q (A)	Q (Al), SA (Aq)
Lead	S	V	SA	Q (PC)	Q (A)	Q (Al), SA (Aq)
Lithium	S		SA	Q (Z)	Q (A)	Q (Al), SA (Aq)
Magnesium	S	V	SA	M (Z)	Q (A)	Q (Al), SA (Aq)
Manganese	S	V	SA	M (Z)	Q (A)	Q (Al), SA (Aq)
Mercury	S	V	SA	Q (PC)	Q (A)	Q (Al), SA (Aq)
Molybdenum		V	SA	Q (Z)	Q (A)	Q (Al), SA (Aq)
Nickel		V	SA		Q (A)	Q (Al), SA (Aq)
Nitrate	S	V	SA		Q	Q (Al), SA (Aq)
Nitrogen (Kjeldahl)	S	V	SA		Q	Q (Al), SA (Aq)
Nitrite	S			M (Z)	Q (A)	SA (Aq)
Odor	S			M (Z)		
Oil & Grease	S			Q (PC)	Q (A)	Q (Al), SA (Aq)
Ortho-phosphate	S			M (Z)		
Pesticides	Q (Z)					SA (Aq)

(See footnote at end of table.)

(continued)

TABLE C-21. (continued)

Parameter	Baseline data gathering program			Development monitoring program		
	Surface water	Springs & seeps	Groundwater	Surface water	Springs & seeps	Groundwater
Phenol	V			Q (PC)	Q (A)	Q (Al), SA (Aq)
Potassium	S	V	SA	M (Z)	Q (A)	Q (Al), SA (Aq)
Radiation, alpha	Q (Z)	V	SA	Q (PC)	S	SA (Al), SA (Aq)
Radiation, beta	Q (Z)	V	SA	Q (PC)	S	SA (Al), SA (Aq)
Rubidium		V				
Scandium		V	SA			
Sediment		V	SA			
Selenium	S	V	SA	Q (PC)	Q (A)	Q (Al), SA (Aq)
Silica	S	V		M (Z)	M	
Silicon dioxide			SA			
Silver		V			Q (A)	Q (Al), SA (Aq)
Sodium	S	V	SA	M (Z)	Q (A)	Q (Al), SA (Aq)
Strontium		V	SA	Q (Z)	Q (A)	Q (Al), SA (Aq)
Sulfate	S	V		M (Z)	Q (A)	Q (Al), SA (Aq)
Sulfide	S		SA	Q (Z)		
Suspended solids	C (Z), X (0)					
Thalium		V				
Titanium		V	SA			
Turbidity	S, C (PC)					
Uranium		V	SA			
Vanadium		V	SA			
Zinc	Q (Z)	V	SA	Q (Z)	Q (A)	Q (Al), SA (Aq)
Zirconium			SA	M (Z, PC)		
pH	S, Q (Z)	V	SA		M (A)	M, Q (Al)
Total dissolved solids		V	SA	M (Z), Q (0, PC)	Q (A)	Q (Al)
Water level			M			M (Al), SA (Aq)
Stream flow	C, (Z), X (0)	V		M (Z), Q (0, PC)	Q, SA, A	
Water temperature	C, (Z), X (0)			M (Z), Q (0, PC)	M (A)	M, Q (Al), SA (Aq)
Dissolved organic carbon		V	SA	M (Z), Q (0, PC)	S	SA (Al), SA (Aq)
Element Scan for Trace Elements	Q (Z)			Q (Z)		
Gross Alpha				Q (Z)		
Gross Beta				Q (Z)		

[a] A = Annually
SA = Semiannually
S = Semimonthly
Q = Quarterly
M = Monthly

C = Continuous
X = Continuous when possible
V = Variable schedule
(Z) = Major gaging stations only
(0) = All gaging stations except major stations

(PC) = Piceance Creek gaging stations
(Al) = Alluvial wells
(Aq) = Deep Aquifers
(A) = All springs and seeps (S-1, S-2, S-3, S-4, S-6, S-7, S-8, S-9, S-10)

An unfiltered and untreated third sample was allowed to settle its suspended material in a cool, dark place. The clear supernatant was analyzed for acidity, alkalinity, color, pH, and CO_2.

Another unfiltered sample was well mixed and used to determine the following:

Nitrogen, ammonia
Nitrogen, organic
Oxygen demand, chemical
Cyanide
Phosphorous
Solids, suspended
Solids, volatile

This sample was kept chilled to prevent decomposition. Field determinations include: (1) temperature, (2) pH, (3) dissolved oxygen, (4) specific conductance, and sometimes, (5) acidity and (6) akalinity. A summary of the surface water quality analytical program requirements is presented in Table C-21.

Stream Flow--

Stream flow baseline data for Tract C-b were gathered at all 13 stream gage stations. All stream gage stations were equipped with Leopold Stevens A35 recorders and analog strip charts. All recorders are weight drive and have stilling wells located on the stream bank, connected to the stream by 5-cm (2-in.) pipes.

Springs and Seeps--

There are nine springs and/or seeps in and around Tract C-b that were monitored during the baseline program for water quality and volume. Many of these springs have also been monitored in the past by USGS and the Colorado Division of Water Resources. A map showing the locations of springs and seeps in the Tract C-b area is presented in Figure C-19.

Samples of water for chemical analysis were obtained from all the springs in the area. Two springs, S-3 and S-9, were selected for detailed study and sampled in February, April, May, June, July, August, and October of 1976 so that short-term fluctuations could be analyzed. Spring flow measurements were made with Standard Parshall flumes. In the case of spring S-9, a more precise measurement was made by installing a turbine-type flowmeter downstream of the flume. Samples for chemical analysis were drawn from Parshall flumes close to the spring itself, except in the case of spring S-3. Because of the shallow depth at this sampling site, water samples had to be drawn at a point further upstream. During the two-year baseline program, a total of 50 samples was taken for water quality analysis. The water quality parameters measured are listed in Table C-21.

Precipitation--

A precipitation recording network was created on and around Tract C-b consisting of five water quality stations, four micro-environment stations, and five modified air quality stations. The locations of these stations are presented in Figure C-20. The stations were equipped with automatic tipping bucket snow-rain gages (with heaters), cumulative precipitation storage gages, or small forestry gages. Samples were taken of snow and rain at two locations around the tract.

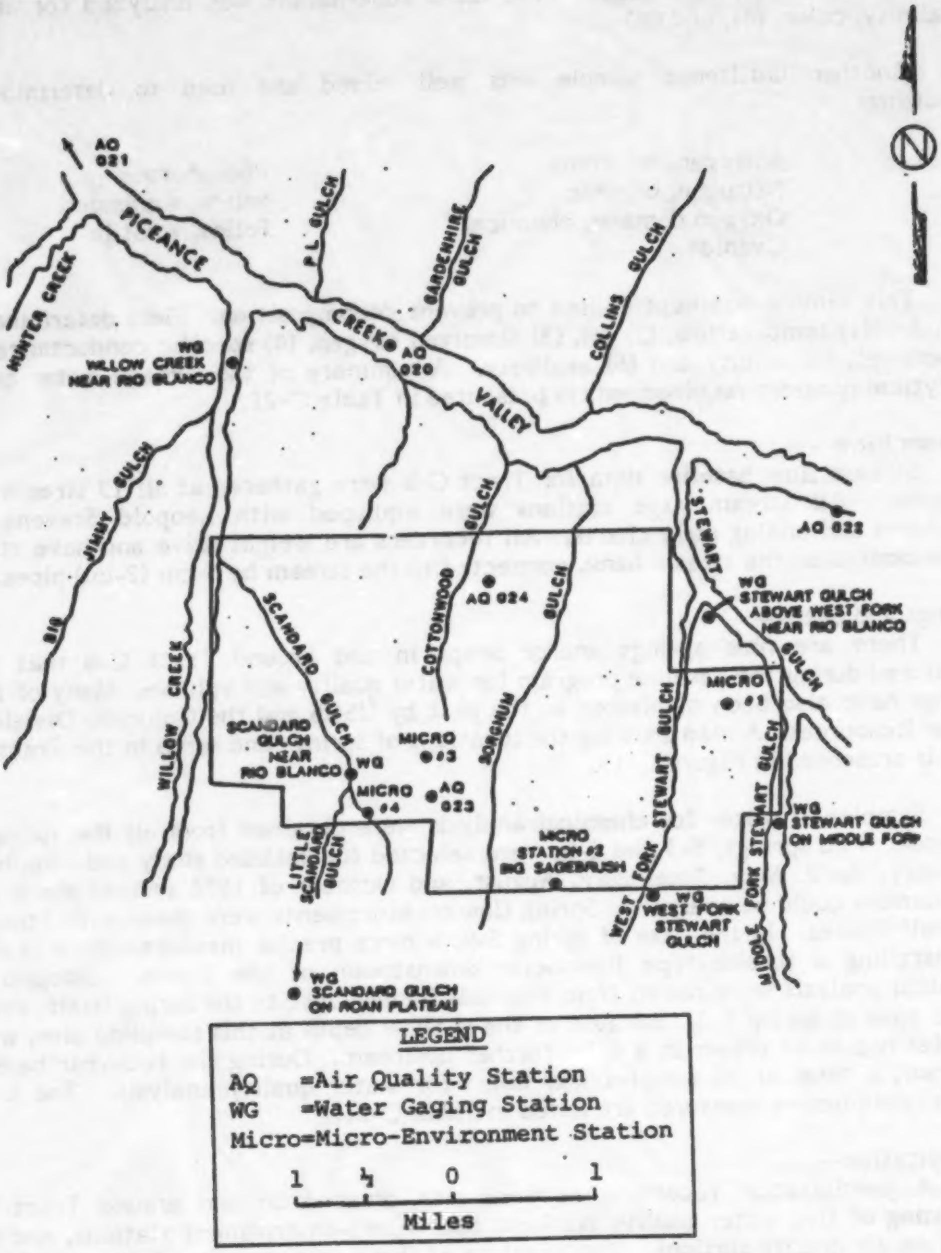
AQ 021
HUNTER CREEK
PICEANCE
P.L. GULCH
GARDENHIRE GULCH
COLLINS GULCH
CREEK
AQ 020
WG WILLOW CREEK NEAR RIO BLANCO
VALLEY
JIMMY GULCH
BIG
WILLOW CREEK
SCANDARD GULCH
COTTONWOOD GULCH
GULCH
STEWART GULCH
AQ 022
AQ 024
WG STEWART GULCH ABOVE WEST FORK NEAR RIO BLANCO
GULCH
MICRO #1
SORGHUM
STEWART GULCH
WEST FORK STEWART
MICRO #3
SCANDARD GULCH NEAR RIO BLANCO WG
MICRO #4
AQ 023
LITTLE SCANDARD GULCH
STEWART GULCH
WG STEWART GULCH ON MIDDLE FORK
MIDDLE FORK STEWART
MICRO STATION #2 BIG SAGEBRUSH
WG WEST FORK STEWART GULCH
WG SCANDARD GULCH ON ROAN PLATEAU
N
LEGEND
AQ =Air Quality Station
WG =Water Gaging Station
Micro=Micro-Environment Station
1 ½ 0 1
Miles

Figure C-20. Precipitation gages on or near Tract C-b.

Water Level Records--

Water table levels were measured and recorded at 12 alluvial wells and 23 deep wells on and around Tract C-b (Figure C-21). Monthly level measurements were taken with manually operated well sounders such as the Powers, M Scope, and Soil Test models. These systems basically consist of two-strand conductive wire marked at 3-m (10-ft) intervals, a reel and handle for winding, and a meter to indicate electrical contact when water fills the gap between two exposed ends of the wire. Initially, 15 wells were equipped for continuous monitoring with a transistorized, level-seeking motor and reel assembly, a Stevens digital tape recorder, and a clock mechanism to punch in hourly measurements. After 1 year, continuous monitoring of wells was discontinued at all but two locations.

Water quality--

Samples for water quality analysis were drawn from the same wells used for groundwater level determination. For the first year, both alluvial and deep wells were sampled every 6 months. Sample frequency was decreased for the deep wells during the second year and increased in selected alluvial wells. Alluvial wells were sampled by pumping water directly with a submersible electric pump. Pumping continued for 1 hr, with water temperature and conductivity being periodically recorded. Samples were filtered in the field under nitrogen pressure and placed in bottles for analysis. Water was pumped from the deep wells by means of a swabbing rig. The water quality parameters analyzed are presented in Table C-21.

Interim Monitoring Program--

The interim surface water and groundwater monitoring program took place from November 1976 to November 1978 and was covered by correspondence between the lessee and the Area Oil Shale Office.

Surface water--Water quality measurements were taken at the surface water quality stations shown in Table C-21. Figure C-19 presents the locations of the surface water stations involved.

Precipitation--Precipitation data collection, managed by the USGS, ended in October 1976. Data were collected at 5 of the 13 water-gaging stations presented in Figure C-19. Precipitation data are also collected at two air quality stations, 020 and 023, by weighing buckets.

Springs and seeps--Water quality data were collected at six springs around the tract. These springs were S-1, S-3, S-6, S-7, S-9, and S-10. The locations of these springs are presented in Figure C-19. A description of the sampling and analyses procedures is not available.

Groundwater--Water quality samples were taken from 11 alluvial wells and from upper and lower aquifer wells. A description of the schedule and methods of sampling and analysis are not available. The locations of these well sites are presented in Figure C-21. Water level data and water quality data are reported in Tables II-A-3 through II-A-8 of the Interim Monitoring Report No. 2 (26).

Development Phase Monitoring Program--

Surface water, springs and seeps, and groundwater are all being monitored for quantity and quality during the development monitoring program phase. The time periods covered during this program and the source of information on the subject are

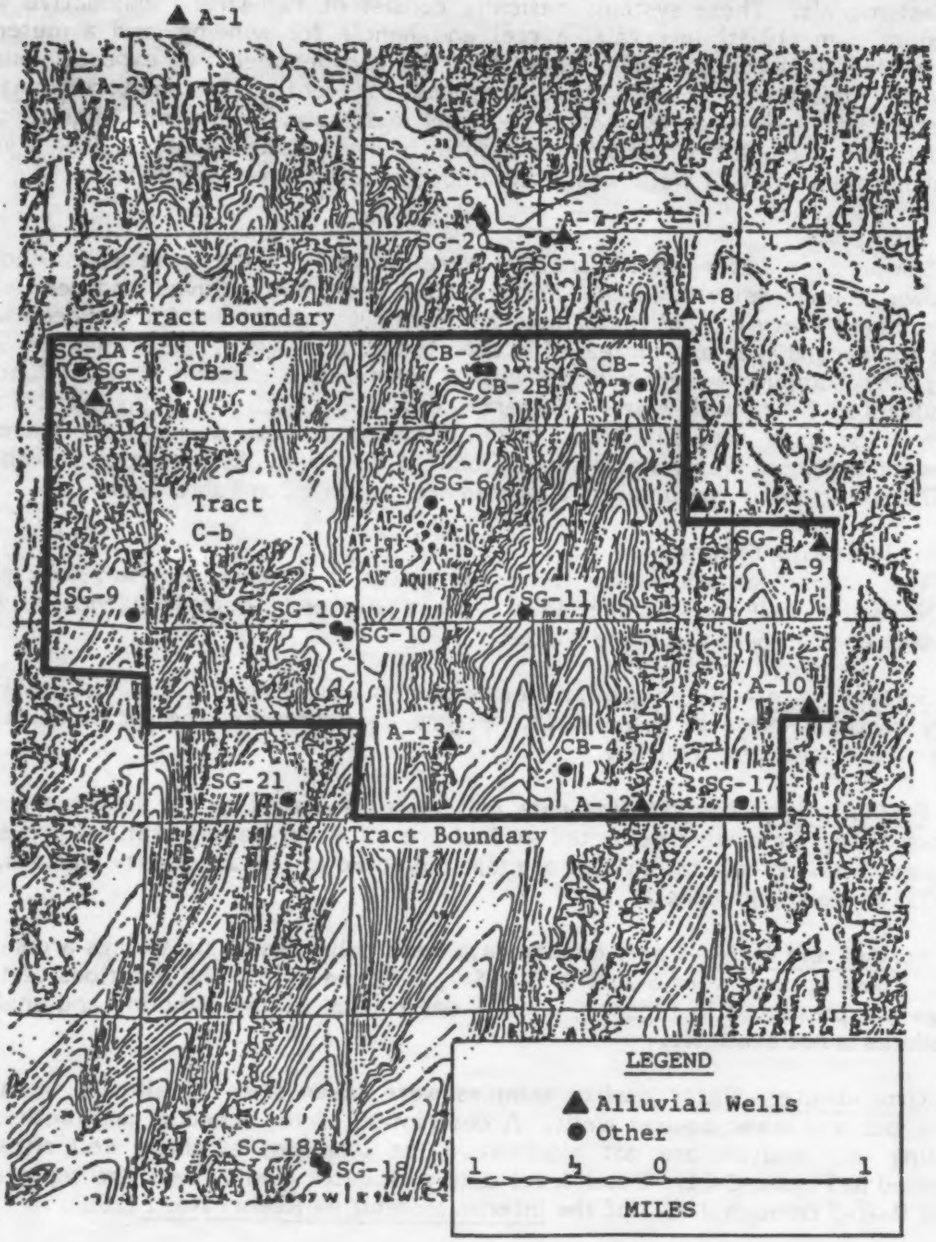
A-1
A-2
A-5
A-6
SG-2
A-7
SG-19
A-8
Tract Boundary
SG-1A
SG-1
CB-1
A-3
CB-2
CB-2B
CB-3
Tract
C-b
SG-6
A-1
AT-1
A-1B
AQUIFER
A11
SG-8
A-9
SG-9
SG-10A
SG-10
SG-11
A-10
A-13
CB-4
SG-21
A-12
SG-17
Tract Boundary
LEGEND
Alluvial Wells
Other
1
½
0
1
MILES
SG-18A
SG-18

Figure 21. Alluvial and deep wells established in the Tract C-b area and used during baseline monitoring.

identical to those discussed in the development air quality and meteorology monitoring discussion.

Surface water--Through a contract arrangement with the USGS, and the Colorado River Water Conservation District, 13 water gaging stations were constructed on and around Tract C-b. Nine of the stations are on ephemeral streams and four are on perennial drainages. The stations contributing to the developmental phase surface water monitoring program are listed in Table C-22. The locations of these stations are presented in Figure C-19. Continuous measurements of temperature and specific conductance will be made at all stations. Dissolved oxygen and pH will be measured continuously at the four major stations, and turbidity will be measured continuously at the two Piceance Creek stations. The remaining water quality parameters to be measured at water quality sampling stations are presented in Table C-18. Monthly, quarterly, and semiannual monitoring will be carried out at: Stations 007, 022, 058, and 061; major stations and stations on ephemeral streams; and major stations, respectively. Methods of analysis will be identical to those utilized in the baseline program.

Springs and seeps--Water quality and quantity will be measured at nine springs and seeps around Tract C-b. The locations of these sampling sites are illustrated in Figure C-19. Water quality will be measured quarterly and quantity will be measured weekly at all stations. The schedule of sampling and the parameters to be measured is outlined below. Methods of analyses are identical to those used in the baseline program.

Weekly. Discharge of the following springs and seeps will be measured on a weekly basis: S-1, S-2, S-3, S-4, S-6, S-7, S-8, S-9, S-10

Monthly. Each month the springs and seeps will be checked for pH,* conductivity,* DO,* and temperature*. If the values are more than 20 percent below minimum baseline values or more than 20 percent above maximum baseline values, additional water quality samples will be obtained.

Quarterly. All springs and seeps will be sampled quarterly and analyzed for the following parameters (starred items are indicator variables):

Ag
*As
Ba
Cd
Cr
Cu
Fe
Hg
Mn
Pb

Mo
Cl
Li
Al
Sr
Se
Zn
*pH
Na
K

Ca
Mg
*Fluoride
*B
Ni
Oil & Grease
Temperature
Kjeldahl-N
COD
BOD

*TDS
SO_4
CO_3
HCO_3
NO_3
Alkalinity
Hardness
*Phenols
*Ammonia

Semiannually. All springs and seeps will be examined semiannually for bacterial contamination (fecal and total bacteria) and radioactivity. DOC fractionation will be examined for two springs to be selected in coordination with the Area Oil Shale Supervisor.

TABLE C-22. SURFACE WATER MONITORING STATIONS FOR THE DEVELOPMENT PHASE AT TRACT C-b

USGS	Station location	Comments
09306007 - MAJOR	Piceance Creek below Rio Blanco	Operate during life of project
09306061 - MAJOR	Piceance Creek at Hunter Creek	Operate during life of project
09306042	Unnamed Gulch west of Cottonwood Gulch	Used to monitor road construction activities, and mine area development; reevaluate at a later date
09306036	Gorghum Gulch at mouth	Operate during life of project
09306033	Sorghum Gulch upstream	Operate during ancillary, reevaluate at a later date
09306039	Cottonwood Gulch at mouth	Operate during life of project
09306022 - MAJOR	Stewart Gulch	Consider reduction if data are stable after period of commercial operations
09306052	Scandard Gulch at mouth	Operate during life of operation
09306058 - MAJOR	Willow Creek	Consider reduction if data are stable after period of commercial operations
09306050	Scandard Gulch upstream	Operate during ancillary development, reevaluate at later date
09306028	West Fork Stewart mouth	Operate during ancillary developemnt, reevaluate at later date
09306025	West Fork Stewart upstream	Operate during ancillary development, reevaluate at later date
09306015	Middle Fork Stewart Gulch	Operate during ancillary development, reevaluate at later date
09306033	Sorghum Gulch upstream	Operate during ancillary development, reevaluate at later date

Annually. All springs and seeps will be examined annually for bromine. All analyses except those for bacteria, radioactivity, and DOC will be performed at the Occidental Oil Co.'s Grand Junction Lab.

Alluvial wells—Water quality and quantity of alluvial wells will be measured at five new and 13 old alluvial test wells. The five new wells (A-2A, A-3A, A-5A, A-6A, and A-7A) will be developed to detect any seepage in the main dumps at Cottonwood and Sorghum Gulches, leakage from proposed storage dams, accidental spills from plant operations, and runoff from construction activities. At this date only one well is completed. The locations of these wells are presented in Figure C-22. Water quality will be measured quarterly at wells A-2A through A-7A and semiannually at wells A-1, A-8, A-9, A-10, A-11, and A-12. Monthly measurements will be made for conductance, pH, temperature, and dissolved oxygen. Water levels will be measured continuously at all stations. The schedule of sampling and parameters to be measured are presented in Table C-21.

Deep Aquifers—

Samples will be taken from 17 upper-aquifer and 14 lower-aquifer wells around Tract C-b. A list of the upper aquifer wells is presented as follows:

Upper aquifer monitoring network:

Before recompletions:

Cb-2	
Cb-4	
AT-1C	#3
SG-1	#2
SG-6	#3
SG-8	#2
SG-9	#2
SG-10A	
SG-11	#3
SG-17	#2
SG-18A	
SG-19	
SG-20	
SG-21	

After recompletions:

UPC_1
UPC_2

Close in during ancillary development:

Cb-2			(UPC)
SG-1	#2	(UPC_1)	
SG-1A		(UPC_2)	
SG-6	#3	(UPC_1),#1	(UPC_2)
SG-10A	#1	(UPC_2),#2	(UPC_1)
SG-20	#2	(UPC_2),#3	(UPC_1)
AT-1B	#3	(UPC_1)	

Remote during ancillary development:

Cb-2	(UPC_2)
Cb-4	(UPC_2)

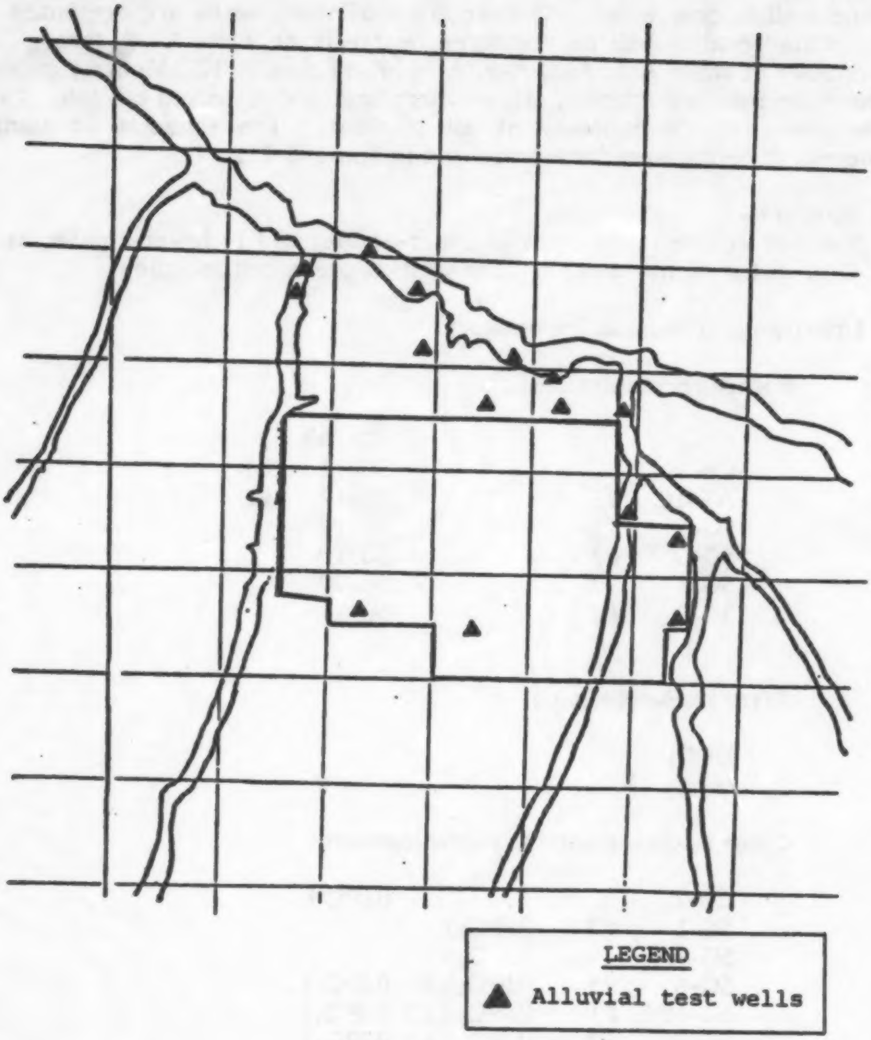
LEGEND
▲ Alluvial test wells

Figure C-22. Alluvial test wells in Tract C-b area during development phase monitoring.

SG-9	#2	(UPC$_2$)
SG-11	#2	(UPC$_2$),#3 (UPC$_1$)
SG-17	#2	(UPC$_2$),#3 (UPC$_1$)
SG-18A	#2	(UPC$_2$),#3 (UPC$_1$)
SG-19		(UPC$_1$)
SG-21	#3	(UPC$_2$),#4 (UPC$_1$)

Additional upper aquifer monitoring wells:

Federally owned:

TH 75 - 5A
TH 75 - 13A
TH 75 - 18A
TH 75 - 9A
TH 75 - 15A
CER RB - D - 02

Owned by Union Oil Co.:

Union 8 - 1

Owned by Atlantic Richfield:

Colony 12 - 596

The locations of these wells are illustrated in Figure C-23. Water quality samples will be taken semiannually and water levels will be taken monthly. A sample will be taken by swabbing. A summary of the sampling schedule and parameters to be measured is presented in Table C-21.

In addition to the monitoring of the conventional water bodies in Tract C-b, water quality measurement will be taken of water in impoundment areas, shale dump sites, and mine drift sumps. Many of the details of these programs are yet to be determined, and hence program specifics are not outlined here.

Biological Resources

Baseline Data Gathering Program--

The biological resource baseline data gathering program was conducted from November 1974 to November 1976. Work on the program was conducted by the Ashland and Occidental Oil Companies. The published reports that have been used as reference material for this report are the First Year Environmental Baseline Program: Annual Summary (23) and the Final Environmental Baseline Program: Final Report (24).

Vegetation--Five areas of interest have been studied in the vegetation data gathering project. These areas are: Phytosociology, productivity, decomposition and litter, herb phenology, and shrub stem growth. The sampling locations for these studies are presented in Figure C-24.

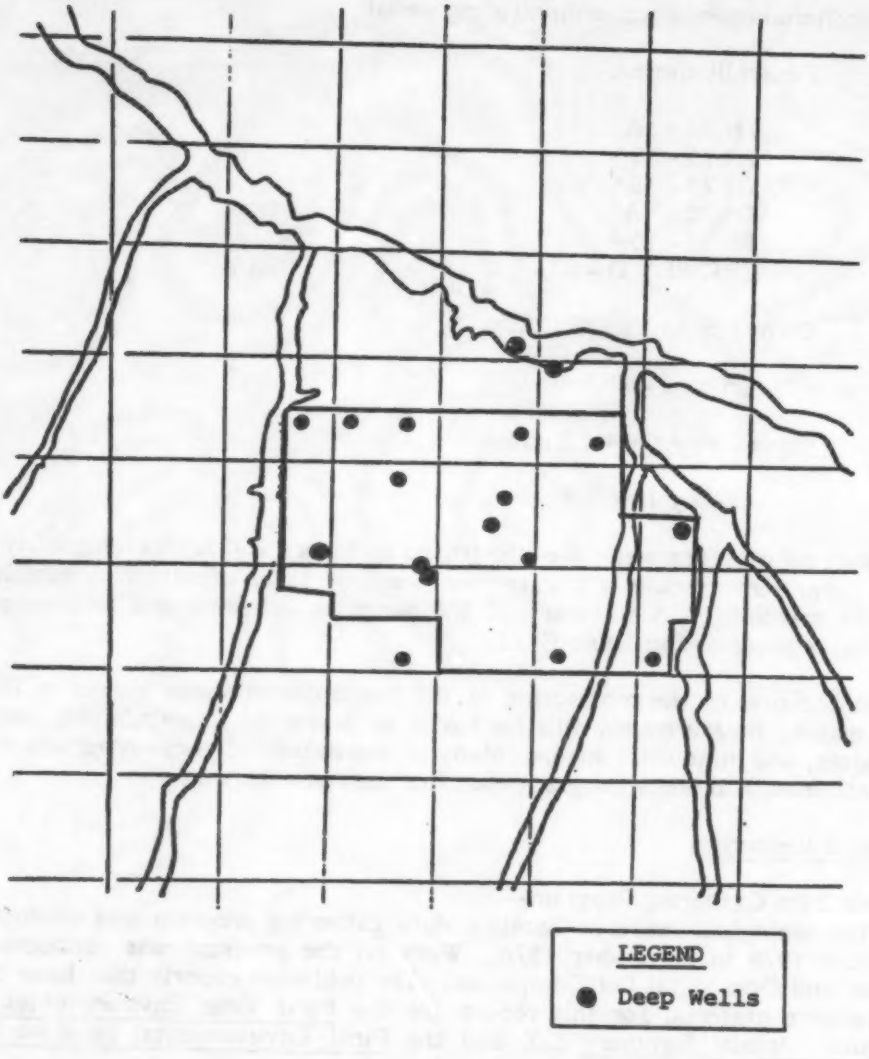
LEGEND
● Deep Wells

Figure C-23. Deep aquifer monitoring well sites in Tract C-b area during development phase monitoring.

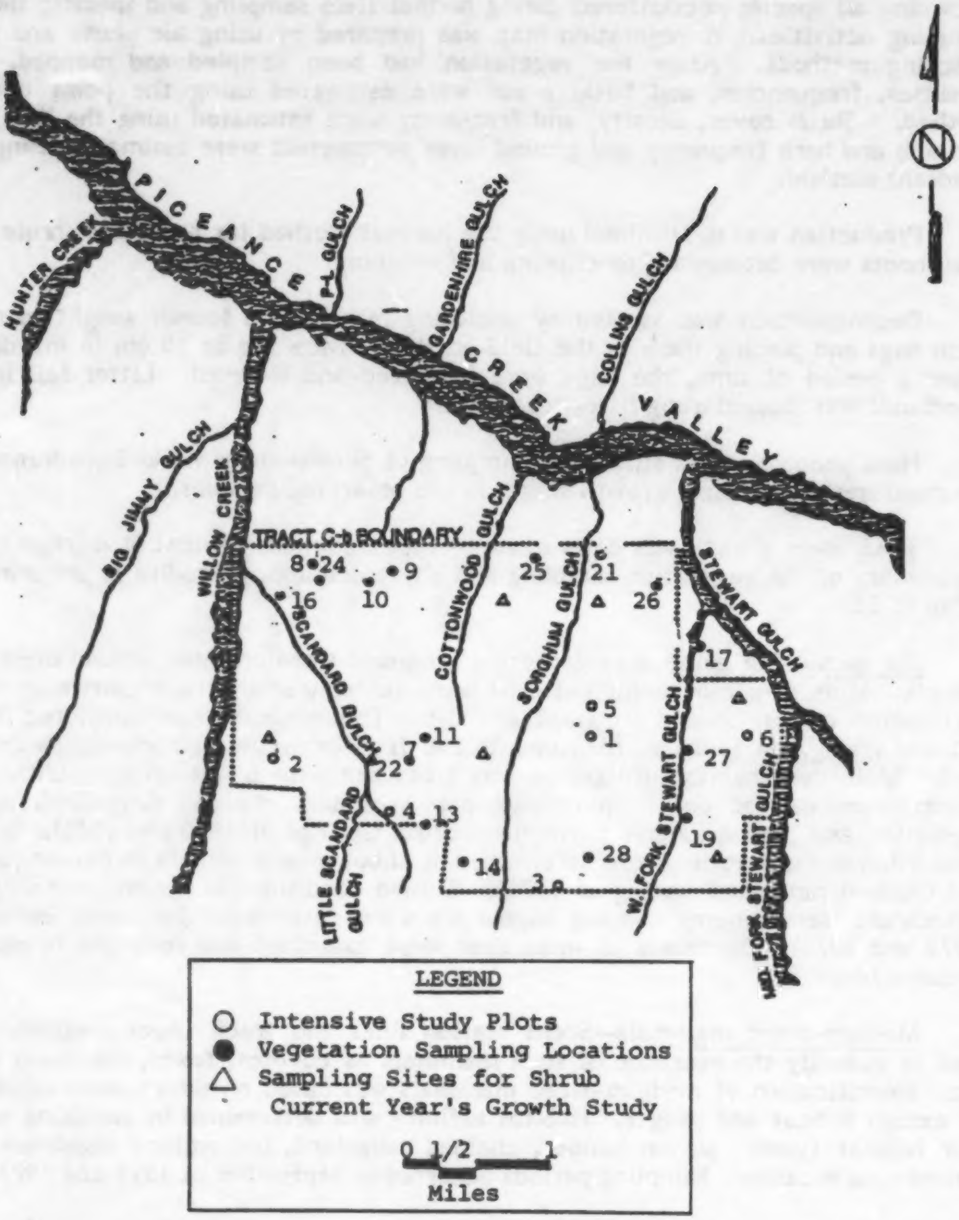
N
HUNTER CREEK
PICEANCE
CREEK
VALLEY
B-1 GULCH
GARDENHIRE GULCH
COLLINS GULCH
BIG JIMMY GULCH
WILLOW CREEK
TRACT C-b BOUNDARY
COTTONWOOD GULCH
SORGHUM GULCH
STEWART GULCH
SCANDARD GULCH
LITTLE SCANDARD GULCH
W. FORK STEWART GULCH
MID. FORK STEWART GULCH
1
2
3
4
5
6
7
8
9
10
11
13
14
16
17
19
21
22
24
25
26
27
28
LEGEND
○ Intensive Study Plots
● Vegetation Sampling Locations
△ Sampling Sites for Shrub Current Year's Growth Study
0 1/2 1
Miles

Figure C-24. Vegetation sampling site locations used during baseline data gathering at Tract C-b.

As part of the phytosociology studies, a list of species was developed by recording all species encountered during normal field sampling and specific species sampling activities. A vegetation map was prepared by using air photo and field checking methods. After the vegetation had been sampled and mapped, tree densities, frequencies, and basal areas were estimated using the point quarter method. Shrub cover, density, and frequency were estimated using the line strip method; and herb frequency and ground layer parameters were estimated using the quadrant method.

Production was determined using the harvest method for herbs and shrubs, and new shoots were determined by clipping and weighing.

Decomposition was studied by enclosing leaves of a known weight in nylon mesh bags and placing them in the field on the surface and at 10 cm (4 in.) depth. After a period of time, the bags were retrieved and weighed. Litter fall in the woodlands was studied using litter traps.

Herb phenology was studied by sampling of permanently marked quadrants and the measurement of eight growth stages in the separated samples.

Shrub stem growth was determined by repeated measurement of marked twigs. A summary of the vegetation sampling and phytosociological studies is presented in Table C-23.

Big game--Big game data gathering programs were oriented around mule deer and elk. Mule deer movement patterns were determined by track counts on major north-south ridges, on and around Tract C-b. This program was conducted during fall and spring. In addition, road counts and fixed-wing aerial reconnaissance was used. Mule deer habitat utilization was measured with pellet group counts. The counts were carried out in pinyon-juniper woodland, chained rangeland, upland sagebrush, and pinyon-juniper bottomland brush (springs of 1975 and 1976). Browse production and utilization were determined by shoot measurements in pinyon-juniper and chained rangeland (spring of 1976). Browse conditions in mountain mahogany, bitterbrush, serviceberry and big sagebrush were determined by visual estimates (1975 and 1976). Carcasses of mule deer were examined and recorded to analyze circumstances.

Medium-sized mammals--Scent station lines and track count methods were used to quantify the presence of such mammals as coyotes, foxes, mountain lions, etc. Identification of medium-sized mammals was based on direct observation for all except bobcat and badger. Habitat affinity was determined by sampling within four habitat types: pinyon-juniper, chained rangeland, bottomland sagebrush, and agricultural meadow. Sampling periods occurred in September of 1974 and 1975.

Small Mammals--Small mammal populations were sampled quantitatively at two grid locations (chained pinyon-juniper rangeland and pinyon-juniper woodland) and completely inventoried on nine satellite grids (all other vegetation areas). Sampling was conducted during the months of May, June, July, August, and September and, in addition, once during December and January on the satellite grids. Analysis of food habitats were conducted on animals trapped on grids one and two.

TABLE C-23. SUMMARY OF PHYTOSOCIOLOGICAL STUDIES AND VEGETATIVE SAMPLING IN BASELINE VEGETATIVE DATA GATHERING PROGRAMS AT TRACT C-b[a]

Type of vegetation	No. of sampled stands	No. of quarter method tree points/stand	No. of shrub transects per stand	No. of herb quadrants 1.0m^2 per stand
Pinyon-juniper woodland	3	40	20	20
Douglas-fir forest	1	--	10	10
Mixed mountain shrub	1	--	20	20
Chained rangeland	3	--	20	20
Upland sagebrush	3	--	20	20
Bottomland sagebrush	2	--	20	20
Greasewood	1	--	20	20
Rabbitbrush	1	--	20	20
Bunchgrass	1	--	20	20
Disturbed Sites (annual weed)	7	--	--	10
Marshes[b]	No sampling data			
Great Basin wild rye[b]	No sampling data			
Riparian community[b]	No sampling data			
Agricultural areas[b]	No sampling data			
Ponds[b]	No sampling data			

[a] Source: Reference 23.

[b] These vegetation types are very limited in extent within the study area. Descriptions of these communities are based on observations only.

Birds--A strip census procedure was implemented to provide data from which bird densities could be extracted. The width of strip transects and methods of density determinations were adjusted for each particular bird group being measured. The species being studied were songbirds, upland gamebirds, waterfowl and shorebirds, and raptors. The sampling schedule is presented in Table C-24.

Amphibians and Reptiles--Sampling of amphibians and reptiles was conducted on small mammal grids 1 and 2 during the months of May through September in 1975 and 1976. Ten transects, 150 m (492 ft) in length, were surveyed on each grid. Identification not founded on grids one and two were made on an opportunistic basis.

Arthropods--Ground and shrub-dwelling arthropods were sampled on grids 1 and 2 using pitfalls spaced 15 m (49 ft) apart. Shrubs were sampled by beating branches to dislodge arboreal insects. Total number of individuals, species diversity, and number of individuals were compared in each shrub species, season, and location. Sampling was carried out between May and September.

Fish--Studies were conducted on local fish to determine species abundance, data on age and size ratios, migration, spanning, distribution, and aquatic habitat.

Other Aquatic Organisms--Data on aquatic organisms in the springs and seeps of Tract C-b were accumulated at 20 sampling stations on the Piceance, Stewart, Willow, and White Rivers. Plankton, periphyton, benthos, and fish samples were taken for analysis.

In addition to the baseline data gathering programs described here, a study was conducted to determine the interrelationships of the Tract C-b ecology and to discuss possible mitigation programs for adverse impacts resulting from Tract C-b development.

Interim Monitoring Program--

The interim biological resources monitoring program took place from November 1976 to November 1978 and was controlled by correspondence between the lessee and the Area Oil Shale Office.

Terrestrial Wildlife Studies--Data were gathered from September 1, 1977, through April 1, 1978. Discussion of the tabular data contained in this section will be restricted to a brief description of the methods used. Figure C-25 depicts the biological program station locations.

Mule Deer Road Counts. Mule deer road counts were conducted in the same manner as during baseline studies. A 56-km (35-mile) length of road was driven (from Rio Blanco to Little Hills), and all deer observed were recorded within 1.6-km (1-mi) intervals. All counts were made during late evenings. Beginning on January 25, 1978, the road count was extended seven miles to include the entire 66-km (41-mi) length of the Piceance Creek road.

Deer Pellet-Group Studies. Deer pellet groups were cleared along 27 transects located in two habitat types, pinyon-juniper and chained rangeland. Pellet groups were cleared from the plots in September 1977.

TABLE C-24. SCHEDULE OF BASELINE DATA COLLECTION ON BIRDS AT TRACT C-b[a]

Census period	Strip transect number										Night owl transects	Waterfowl counts	Raptor nest survey	Pellet cast collections
	1	2	3	4	5A	5B	6	7A	7B	8				
October 1974	x^1[b]	x^1	x^1	x^1	x^1		x^1	x^1		x^1		x	x	
November 1974	x^1	x^1	x^1	x^1							x	x		
January 1975	x^1	x^1	x^1	x^1	x^1		x^1	x^1		x^1		x		
March 1975	x^1	x^1	x^1	x^1								x		x
May 1975	x^1	x^1	x^1	x^1	x^1		x^1	x^1		x^1	x	x	x	x
July 1975	x^1	x^1	x^1	x^1								x		
September 1975	x^1	x^1	x^1	x^1	x^1		x^1	x^1		x^1		x		
October 1975														x
December 1975											x		x	x
February 1976	x^3	x^3	x^3	x^3		x^3	x^1		x^1	x^1		x		x
April 1976	x^3	x^3	x^3	x^3		x^3	x^1		x^1	x^1		x		x
May 1976											x	x	x	
June 1976	x^3	x^3	x^3	x^3		x^3	x^1		x^1	x^1				
July 1976	x^1	x^1	x^1	x^1								x		x

[a] Source: Reference 23.

[b] x^1 = Transect sampled once during census period.
x^3 = Transect sampled in triplicate during census period.

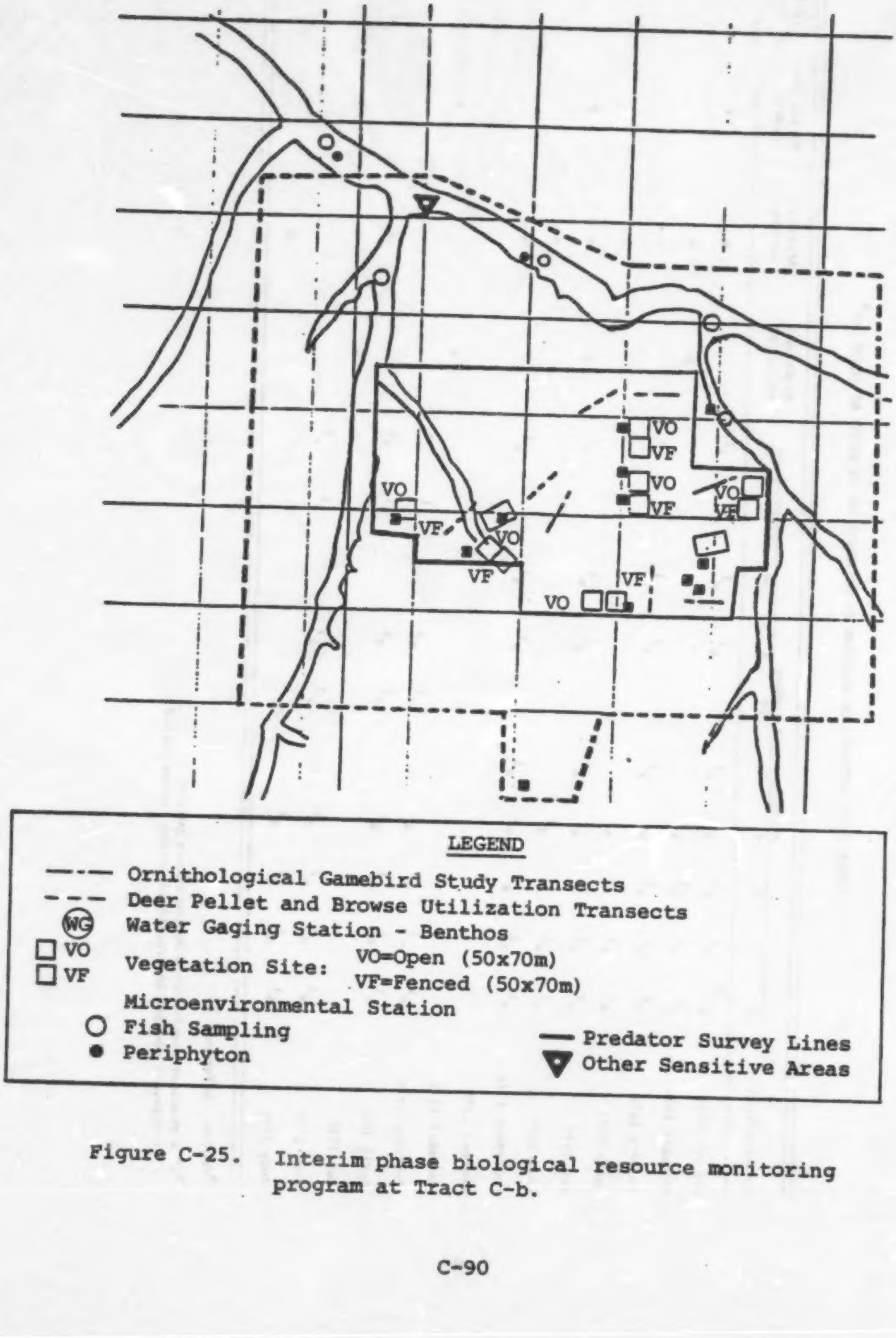
VO
VF
VO
VF
VO
VF
VO
VF
VO
VF
VO
LEGEND
Ornithological Gamebird Study Transects
Deer Pellet and Browse Utilization Transects
WG
Water Gaging Station - Benthos
VO
VF
Vegetation Site:
VO=Open (50x70m)
VF=Fenced (50x70m)
Microenvironmental Station
Fish Sampling
Periphyton
Predator Survey Lines
Other Sensitive Areas

Figure C-25. Interim phase biological resource monitoring program at Tract C-b.

Deer Road Kill. The deer road kill count was started in October and concluded in May 1978. Counts were made from a vehicle driving approximately 50 kmph (30 mph). When a carcass was found it was tagged, so as not to be recounted. Carcasses were aged using tooth wear criteria. Mileage from starting point was noted. Other road kills (domestic and wild) were also noted; only large animals were tagged.

Deer Mortality. No studies were conducted during this period. The study will be conducted in June, as described in the Development Monitoring Program for Oil Shale Tract C-b (27).

Age Class Composition of Deer. Age class estimates of deer were obtained by observations of deer in the agricultural meadows near Piceance Creek during November 1977.

Coyote Abundance. The coyote scent station transects were conducted in October in the same manner as baseline studies. The only change was the addition of two 24-km (15-mi) transects on and around Tract C-b.

Lagomorphs. Lagomorph pellet counts were conducted in the same plots that were used for deer pellet counts. Plots were cleared of pellets in September 1977.

Small Mammals. No studies were conducted during this period; however, some changes were made in the program. The grids were changed to live transects. There were four study sites: Two in agricultural meadows, one in pinyon-juniper woodland, and one in chained pinyon-juniper. The meadow transects are north of Tract C-b, while the other two transects are on the tract. The two study sites in the meadows have four transects apiece, while the remaining sites have two transects apiece. Each transect consists of 25 live traps at 15 m (49 ft) intervals. Traps were checked for three consecutive nights. Studies were conducted in June and in September.

Avifauna. No study was conducted during this period; however, some changes were made when the study was conducted in May 1978. Sampling frequency was increased from three to four. Also, one international census plot was conducted this year to compare results with the Emlen strip transect method.

Shrub Productivity and Utilization. Browse shrub species were tagged in September along the 27 deer pellet group transects. Methods of tagging were the same as those in baseline studies; however, some changes have been made. Only bitterbrush were clipped and measured as in baseline studies. Mountain mahogany was discontinued. Visual estimates of sagebrush were conducted along the same deer transects. Periods of sampling remained the same: June and September.

Aquatic studies--Aquatic sampling was reduced from baseline studies, both in sampling frequency and locations (see Figure C-25). Periphyton was not done from September to March. The sampling period began in April 1978 and ran through September 1978. Benthos was sampled when possible. Fish studies were systems-dependent (they were done if a significant difference was noted in periphyton or benthos).

Benthic invertebrates were collected monthly by the USGS at three locations: Piceance Creek near Rio Blanco, Willow Creek, and Piceance Creek upstream from Hunter Creek. Some winter months were not sampled because of ice on the creek. Benthos studies were done by the USGS at monthly intervals. Benthic invertebrates were identified to order, family, and species.

Periphyton data were not collected for this period. Periphyton sampling was an important indicator of water quality. Beginning in April 1978, and running through September 1978, periphyton was sampled every 30 days, with collectors used continuously.

Terrestrial vegetation studies--

Vegetation Community Structure and Composition. Data were not collected for the winter period. Starting in 1978, sampling was carried out on a 3-year rotational basis. Each plot will be sampled every 3 years, two plots each year.

Herbaceous Productivity and Utilization. Data were not collected for the winter period. In 1978, sampling continued on the exclosure and unfenced plots. A new evaluation tool was used this year--range cages in major vegetation types provided additional vegetation type productivity and utilization data.

General Condition of Vegetation with Colored Infrared Photography. Vegetation condition was not done on a routine basis previously, but it was planned for 1978 and thereafter to detect vegetation stresses and changes.

Development Phase Monitoring Program--

The environmental monitoring program that is taking place now during the development phase of the Tract C-b oil shale project was initiated in February 1978 and will continue through project development. The source of information for the biological resources section of this report is the Development Monitoring Program Supplement (27).

Big game - deer--Deer days of use will be estimated by pellet-group counts. Fifteen permanent transects are located in the chained pinyon-juniper, and 12 transects are located in the pinyon-juniper woodland. Each transect consists of 20 plots that are raked free of pellets in the fall and surveyed in the spring.

Distribution and migration of deer will be determined by use of vehicle counts. Weekly sampling will be conducted between mid-September and the end of May. Deer counts will begin 15 min before dusk, and the deer will be counted at 1.6 km (1-mi) intervals.

Deer mortality will be determined by two methods: road kill and permanent plot surveys. The deer will be located, plotted, and identified by age using the teeth wear methods. The location of the deer mortality plots is illustrated in Figure C-26. Mule deer age class will be determined by observation in meadows within a 8-km (5-mi) radius of Tract C-b. Points on buck antlers will be counted once in fall and once in spring.

Other animals--Medium-sized animals, including coyotes and lagomorphs (cottontails and jackrabbits), will be surveyed on and around Tract C-b. Coyote

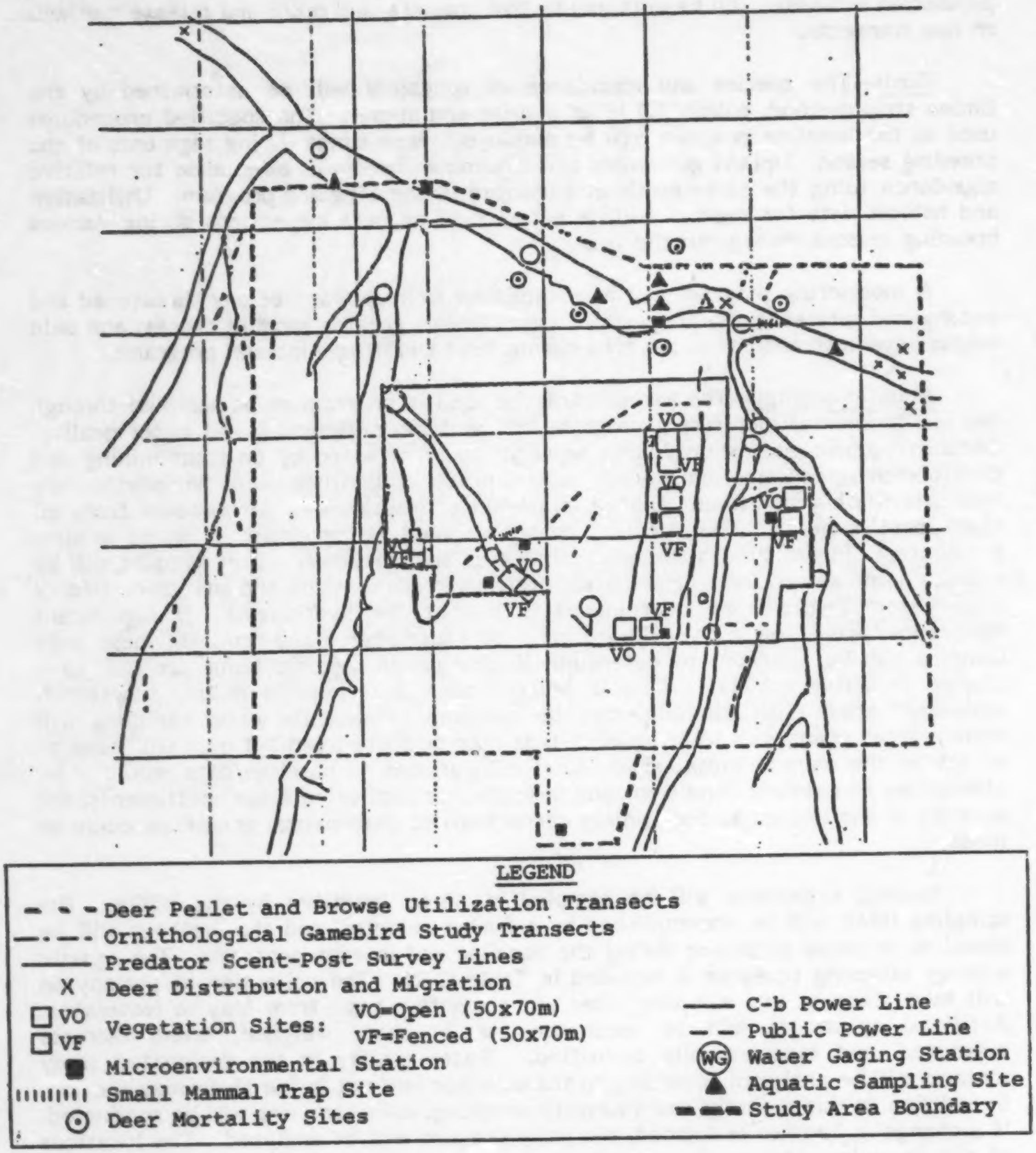
VO
VF
VO
VF
VO
VF
VO
VF
VO
VF
VF
VO
LEGEND
Deer Pellet and Browse Utilization Transects
Ornithological Gamebird Study Transects
Predator Scent-Post Survey Lines
X Deer Distribution and Migration
VO
VF
Vegetation Sites:
VO=Open (50x70m)
VF=Fenced (50x70m)
Microenvironmental Station
Small Mammal Trap Site
Deer Mortality Sites
C-b Power Line
Public Power Line
WG Water Gaging Station
Aquatic Sampling Site
Study Area Boundary

Figure C-26. Developmental phase biological resource monitoring program sites at Tract C-b.

abundance will be determined using the scent post survey. Lagomorphs will be counted for density using pellet counts on established plots. Small mammal population estimates will be obtained by live trapping and mark and release methods on line transects.

Birds--The species and abundance of songbirds will be determined by the Emlen strip method, within 3.5 hr of sunrise and sunset. The specified procedures used in the baseline program will be employed three times during segments of the breeding season. Upland gamebirds and mourning doves will be studied for relative abundance using the same methods employed in the songbird program. Utilization and habitat data for raptors will be established by nest inspections during various breeding seasons throughout the year.

A monitoring program will be established to keep track of any threatened and endangered species in the area. Peregrine falcons, greater sandhill cranes, and bald eagles have been noticed in the area during the baseline and interim programs.

Aquatic ecology--The variables of the aquatic program to be sampled through the environmental monitoring program are benthos, periphyton, and water quality. Because aquatic ecosystems could be secondarily affected by on-tract mining and development, aquatic monitoring is essential. Benthos and periphyton are "indicators" of a significant change in stream characteristics downstream from oil shale development. The specific changes should be apparent in water quality parameters. In addition to the quarterly water analysis, daily water samples will be collected and stored for a month after periphyton are sampled and analyzed. (Water quality sampling will be coordinated with that for hydrology.) If significant differences are noted in the primary indicators (periphyton and benthos), these daily samples can be analyzed to determine if changes in aquatic biota are due to a change in water quality. Also, if a significant difference is noted, a systems-dependent study (fish shocking) may be initiated. The daily water sampling will reflect rapid changes in water quality that may be short-lived but may still have an effect on the aquatic biota. Statistical comparisons to baseline data would show alterations of baseline conditions and indicate, through correlation coefficients, the severity of the impact so that timely corrections of detrimental conditions could be made.

Benthic organisms will be sampled at three locations by the USGS. The sampling itself will be accomplished by a Surber sampler, and the methods will be identical to those employed during the baseline and interim programs. The aquatic ecology sampling schedule is included in Table C-25. The collection of periphyton will take place at two sampling sites, on a monthly basis from May to November. Artificial substrates will be incubated for 21 days, weighed, dried, biomass extracted, and taxonomically identified. Water quality in the designated study streams will be analyzed according to the schedule laid out in the Hydrology section. In addition to this monthly and quarterly sampling, daily sampling will be conducted. If a change in benthos is noticed, the daily samples will be analyzed. The locations of the sampling sites in the aquatic ecology monitoring program are presented in Figure C-26.

Terrestrial vegetation studies--Two control and two development plots have been established representing the two major habitat types in the Tract C-b area, namely, chained pinyon-juniper rangeland, and pinyon-juniper woodland. These plots

TABLE C-25. SUMMARY OF DEVELOPMENT PHASE BIOLOGICAL RESOURCE MONITORING PROGRAM

Variable	Sampling period and/or intensity	Approximate starting date
Deer days of use	Once per year in chained pinyon-juniper rangelands and pinyon-juniper woodlands.	June 1
Distribution and migration	Mid-September through May - Highway 64 to Rio Blanco.	September 15
Road kills	Mid-September through May - Highway 64 to Rio Blanco.	September
Mortality	Once each year in spring in lateral draws and bottomland sagebrush north of Tract.	June 1
Age-class	Twice each year in fall and spring in meadows adjacent to Piceance Creek.	November and April
Medium-sized mammals:		
Coyote abundance	Once each year along 24 km of road segments on Tract C-b and 24-km segments west of Tract C-b.	September
Lagomorph abundance	Once each year in the chained pinyon-juniper rangelands and pinyon-juniper woodlands.	June 1
Small mammals:	Twice per year in spring and early fall in chained pinyon-juniper rangelands, pinyon-juniper woodlands, and bottomland hay meadows.	June 1 and September 15
Avifauna:		
Songbird relative abundance and species composition	Three times each year in pinyon-juniper rangelands and pinyon-juniper woodlands.	May 15
Upland gamebirds:		
Mourning dove relative abundance	Three times each year in pinyon-juniper rangelands and pinyon-juniper woodlands.	May 15

(continued)

TABLE C-25. (continued)

Variable	Sampling period and/or intensity	Approximate starting date
Raptor activity	Twice each year during the appropriate breeding season, nest occupancy will be checked. Also, throughout the year, all raptor sightings within the study boundary will be recorded.	March and June
Aquatic ecology:		
Benthos	Monthly - except winter, when inaccessible.	April and September
Periphyton	Monthly through growing season.	
Water quality	Daily with analysis only if significant difference is noted in Benthos or Periphyton.	
Terrestrial vegetation:		
Community structure and composition	Three-year rotational sampling in each of the six extensive study plots established in the four major vegetation types.	June 10
Herbaceous productivity and utilization	Once each year in four exclosure locations and 65 range cages established in the four major vegetation types. In addition, five line transects for sampling the fertilization plots.	July 1 - Exclosures, August 1 Cages, transects
Shrub productivity and utilization	Once each year in six exclosure locations and 60 range cages established in the four major vegetation types.	July 1
Shrub productivity and utilization	Twice each year along 31 transects used for deer days of use.	June and September
General condition of vegetation	Yearly over all the tract.	June 10 (starting in 1979)
Micro-climactic studies	Twice monthly at ten baseline sites.	

will be surveyed on a 3-year rotational basis; each plot will be sampled every 2 years (two plots each year). Shrub frequency, density, cover, cover by litter, soil, rock, lichens, mosses, and woody seedlings will be measured. Six sites (two development sites and two control sites for pinyon-juniper and chained pinyon-juniper, and two control sites for bottomland sagebrush) will be utilized to estimate herb production and utilization. The vegetation will be clipped, using the double sampling approach, weighed, and compared to vegetation samples from nonfenced areas. Additional determinations are made using 40 range cages and by visual investigation. Shrub utilization and production is determined by taking measured samples along the same development and control transects used for deer days of use. Visual estimation is also used. The condition of the general vegetation is determined through the use of aerial photogrammetry, including color-infrared and color film taken by fixed-wing aircraft. There are 10 established microclimatic stations in Tract C-b--five on control sites and five on development sites (Figure C-26). Each station is monitored twice monthly for air temperature, soil temperature, precipitation, snow depth, and moisture content.

Revegetation of the disturbed sites in the Tract C-b project area will be monitored for vegetative structure, composition, and productivity.

In addition to the established biological resource monitoring projects, additional projects will be initiated if a change in a local ecosystem is detected by measurement of an indicator variable moving above a threshold level. Such additional programs are referred to as systems dependent monitoring programs. For example, these programs might include the sampling of fish as a reflection of change in benthos or periphyton, the measurement of pollutants in plant tissue if significant differences in herb production are noticed, and the measurement of toxicity in plants, soils, and air.

Solid Wastes Disposal, Revegetation

Baseline Data Gathering Program--

During the time period covered by baseline data gathering operations no experimental revegetation studies were conducted at Tract C-b. However, a close watch was kept on the revegetation studies being done by the Occidental Oil Co. and the Colony Development Operation to stay informed of any problems and potential solutions.

Interim Monitoring Program--

The interim solid waste, revegetation monitoring program took place from November 1976 to November 1978 and was controlled by correspondence between the lessee and the Area Oil Shale Office.

Development Phase Monitoring Program--

In 1979, an experimental plot was constructed to test the reclamation methodology planned for spent shale disposal embankments. Plant species, fertilization, mulches, and irrigation are tested. Half the plot is irrigated with 1233 cubic meters (1 acre-ft) of water over a 2-year period and the other half is not irrigated. Both sides have independent drains to collect any leachate. The leachate quality is compared with rainfall to determine effects on water quality from an embankment of 45.7 cm (18 in.) of soil-like material over raw shale. Parameters to be measured are the same ones that are important for the hydrology program with regard to impoundments (see Table C-22).

A program of revegetation will be submitted to the Area Oil Shale Supervisor before any solid waste disposal from oil shale mining and/or retorting.

Noise

Baseline Data Gathering Program--

The baseline noise monitoring program was conducted between November 1974 and October 1976. The two published documents that have been used most for reference in this report are the First Year Environmental Baseline Report (23) and the Final Environmental Baseline Report (24).

Two sets of noise measurements were made on Tract C-b during baseline monitoring. One set of measurements was geared toward traffic noise, and the other toward ambient background noise. The traffic noise was measured by the State of Colorado Highway Department at 13 locations in the general area of the Piceance Basin. The State Highway Department provided a correlation curve to estimate noise from traffic level at locations 152 m (500 ft) from the highway. Additional noise level measurements were made at 14 locations around Tract C-b to determine background noise levels. The locations of these sites are presented in Figure C-27. The measurements were made from September 1975 to October 1976 with a General Radio Type 1565-B sound level meter. A windscreen was used for all outdoor measurements and no measurements were made with winds greater than 48 kmph (30 mph). The microphone was pointed at right angles to the direction of the estimated noise path.

Interim Monitoring Program--

The interim noise monitoring program took place from November 1976 to November 1978 and was controlled by correspondence between the lessee and the Area Oil Shale Office.

Traffic noise measurements were made 1 day/month approximately at morning shift change at Stations II and XV (Figure C-27) along Piceance Creek Road and on the access road at the tract boundary, respectively. The General Radio 1565 sound level meter was used to measure peak noise levels at A weighting. Background levels (i.e., no traffic) were obtained the same day at A, B, and C weightings.

Tract noise surveillance has been determined since February 1978 at Station XV, located in the vicinity of proposed ancillary development activity. The B & K precision sound level meter (model 2203) was located on the tract northern boundary. Continuous noise measurements at A weighting were made for 24 hr every sixth day. The single station acted as a control during off-shift or quiet intervals, and as a development site during operational periods of the day.

Development Phase Monitoring Program--

During the development phase monitoring program, a continuation of the baseline and interim noise measurement program is being accomplished. The program is described in the Development Monitoring Program for Tract C-b (20).

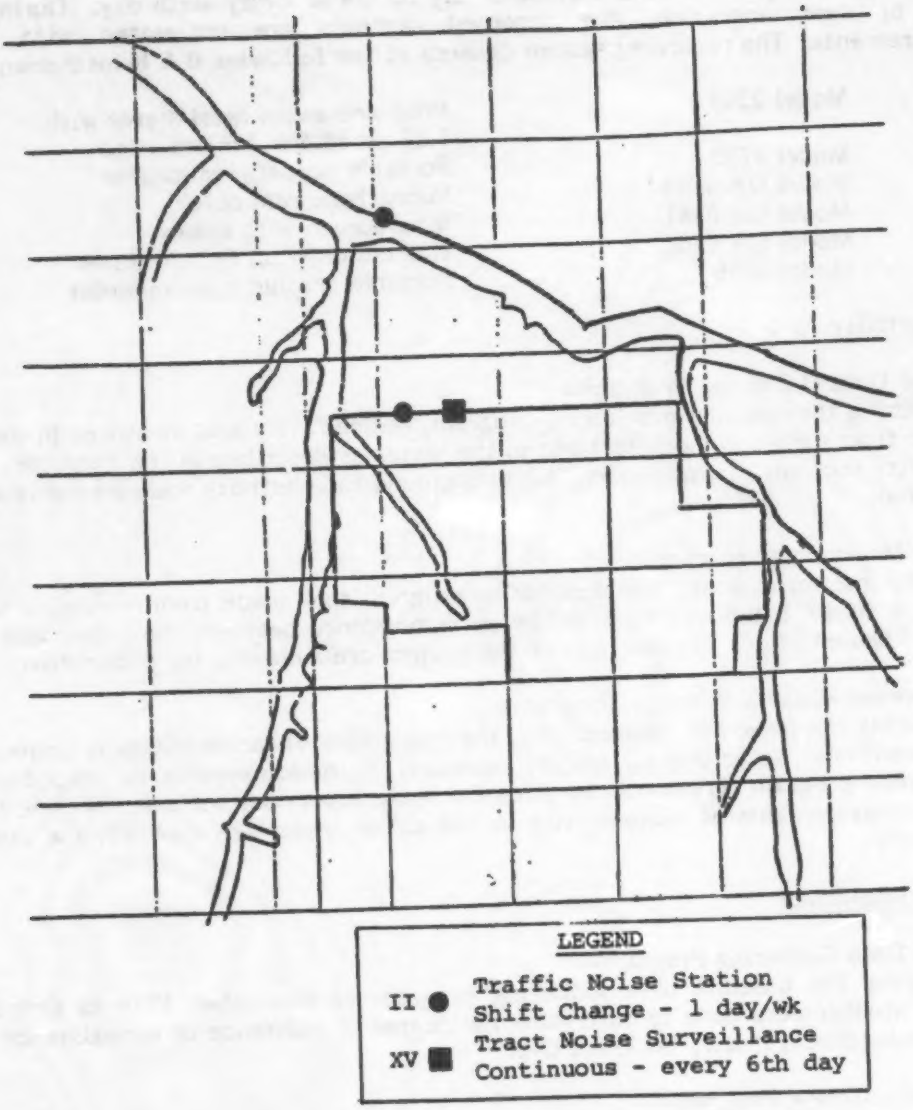
LEGEND
II ● Traffic Noise Station
Shift Change - 1 day/wk
XV ■ Tract Noise Surveillance
Continuous - every 6th day

Figure C-27. Environmental noise monitoring network at Tract C-b.

Measurements are made of traffic and ambient tract noise as a continuation of the baseline and interim programs. Traffic noises are measured at Stations II and XV of Figure C-27. Peak and background noise levels are measured weekly with a General Radio 1565 sound level meter and recorded monthly.

Continuous background tract noises are measured at Station XV on the northern boundary of Tract C-b continuously for 24 hr every sixth day. During the peak of deer migration, the recorded numbers are correlated with noise measurements. The recording system consists of the following B & K instruments:

Model 2203	Precision sound level meter with 1.27 cm (0.5-in.) microphone
Model 4230	Portable acoustic calibrator
Model UA 0393	Microphone rain cover
Model UA 0381	Wind screen with spikes
Model UA 0308	1.27 cm (0.5-in.) Dehumidifier
Model 2306	Portable graphic level recorder

Radioactivity

Baseline Data Gathering Program--

During the baseline monitoring program, radioactivity was measured in the air (residue from high-volume filter) and in the water as described in the hydrology and air quality sections of this report. No background radioactivity measurements were conducted.

Interim Monitoring Program--

The interim radioactivity monitoring program took place from November 1976 to November 1978 and was reported by correspondence between the lessee and the Area Oil Shale Office. No specifics on the project are available for publication.

Development Phase Monitoring Program--

During the period of development, the monitoring of radioactivity is limited to the conventional water and air quality radioactivity measurements as described in the baseline program report. If the Area Oil Shale Supervisor feels at any time that further measurements of radioactivity in the air or water are merited, the lessee will comply.

Surface Subsidence

Baseline Data Gathering Program--

During the baseline data gathering program of November 1974 to October 1976, no studies were done to determine the degree of existence or nonexistence of surface subsidence, if any, on Tract C-b.

Interim Monitoring Program--

The interim surface subsidence monitoring program took place from November 1976 to November 1978 and was reported by correspondence between the lessee and the Area Oil Shale Office. No specifics on the project are available for publication.

Development Phase Monitoring Program—

A surface and underground subsidence monitoring network will be designed and will be in place and operational before the initial rubblization blast.

The surface monitoring network will consist of the following:

For the two- and four-retort auxiliary phase developments:

1. Two mutually perpendicular level lines meeting at the center of the module.
2. Level stations spaced at approximately 30.5 m (100 ft) apart.
3. Base control run to stable ground at each of the level lines.
4. Control lines extending approximately 73.2 m (240 ft) beyond the mining development.

For the commercial development:

1. Parallel level lines are to be established along the barrier pillars and along the middle of the panel.
2. Level stations are to be installed at approximately 30.5-m (100-ft) intervals along the level lines.
3. Cross links between lines will be established at 91.5-m (300-ft) intervals with individual stations at approximately 30.5-m (100-ft) intervals

The equipment and procedures for use in the level surveys are:

1. A self-leveling engineer level, optical micrometer, and invar staves will be used for measurements.
2. Normal differential-leveling surveying techniques will be used to alleviate surface effect as a result of moisture and temperature
3. Permanent, standard level monuments will be used to alleviate surface effect as a result of moisture and temperature.
4. The expected accuracy of single measurements are on the order of 0.015 cm (0.0005 ft).

The underground monitoring effect includes:

1. The mine surveying network will be utilized to determine vertical and horizontal displacements on all mining levels.
2. A resurvey of the underground survey network will be undertaken at yearly intervals, and changes in vertical and horizontal distances will be tabulated.

For the distance and angle measurements for horizontal and vertical displacements:

1. Distances are to be measured with an electronic distance-measuring device from selected base stations.

2. Angles are to be measured with a theodolite (1-s accuracy) from selected base stations

3. Adequate primary, secondary, and tertiary base controls will be established to determine horizontal changes between level stations.

The equipment and procedures for use in distance and angular surveys are:

1. An electric distance-measuring device and accessories will be used to measure distances.

2. A theodolite (1-s accuracy) will be used for angular measurements.

3. A primary triangulation network will be established on stable ground and maintained for the project life.

For the aerial photography to inventory the physical features of the site, the work includes:

1. A 1/6000 scale photography to inventory site physical condition. This photography occurs at yearly intervals in black and white. It is the same photography as in:

2. A 1/1000-scale photography over active mining areas to provide the details of subsidence-caused effects on the surface and to photograph at yearly intervals areas mined in the previous 2 years, and areas in which mining is to be undertaken in the next year.

3. Equipment and procedures for aerial photography include standard air photo techniques to produce stereo pairs and controlled mosaics, field premarking to be established for the project life and renewed annually before photographing, and taking of the photographs at the same time each year in the spring.

For the specific monitoring in the shaft pillar areas the work includes:

1. Two lines at right angles across each shaft pillar that will extend into the rubblized areas.

2. Level stations established at approximately 30.5 m (100 ft) intervals.

3. Five tiltmeters established in each shaft pillar (one tiltmeter is located in each quadrant of the pillar near the boundary with rubblized rock, and the fifth tiltmeter is located near the shaft pillar center.

For the surface vibration measurements the work includes:

1. Establishment of three continuous-reading accelerometer stations at widely-spaced intervals at surface.
2. Mounting of accelerometers on concrete pads coupled to bedrock (location on stable ground is not influenced by rubblized retorts).
3. Provision of a quantified assessment, by means of accelerometer data, of the magnitude and duration of the rubblization blast-induced vibrations and, in addition, any pinpointing of any earthquakes that might be induced onsite.

TRACTS U-a and U-b

Air Resources

Baseline Data Gathering Program--

Baseline Data Gathering Programs were conducted in accordance with the terms of Oil Shale Leases U-25918 (U-a), and U-26194 (U-b) as issued on June 1, 1974, by the U.S. Department of the Interior. Both tracts are in Uinta County, Utah, approximately 80 km (50 mi) southeast of Vernal, Utah. The tracts are each 2073 ha (5,120 acres) and are contiguous with one another (see Figure C-28).

The information contained in this report was taken from First Year Environmental Baseline Report, White River Shale Project, Tracts U-a, U-b, Volumes 1 and 2 (30), and Final Environmental Baseline Report: White River Shale Project, Tracts U-a, U-b (31).

White River Shale Project (WRSP) (Sunco Energy Development Co., Sohio, and Phillips Petroleum Co.) baseline studies were conducted between the years 1974 and 1977 by VTN Colorado, Inc. and the following subcontractors:

1. AeroVironment, Inc. (Air Resources)
2. Utah State University
    - Dr. Cyrus McKell, Vegetation
    - Dr. Ned Bohart, Terrestrial Invertebrates
    - Dr. John Skujins, Microbiology
    - Dr. Don Dwyer, Range Science
    - Dr. David Bolph, Ecological Interrelationships
    - Dr. Martha Bolph, Ecological Interrelationships
    - Mr. Alvin Southard, Soils
3. Utah Division of Wildlife Resources
4. U.S. Geological Survey
5. Utah Historical Society, Archaeology
    - Dr. David Madsen

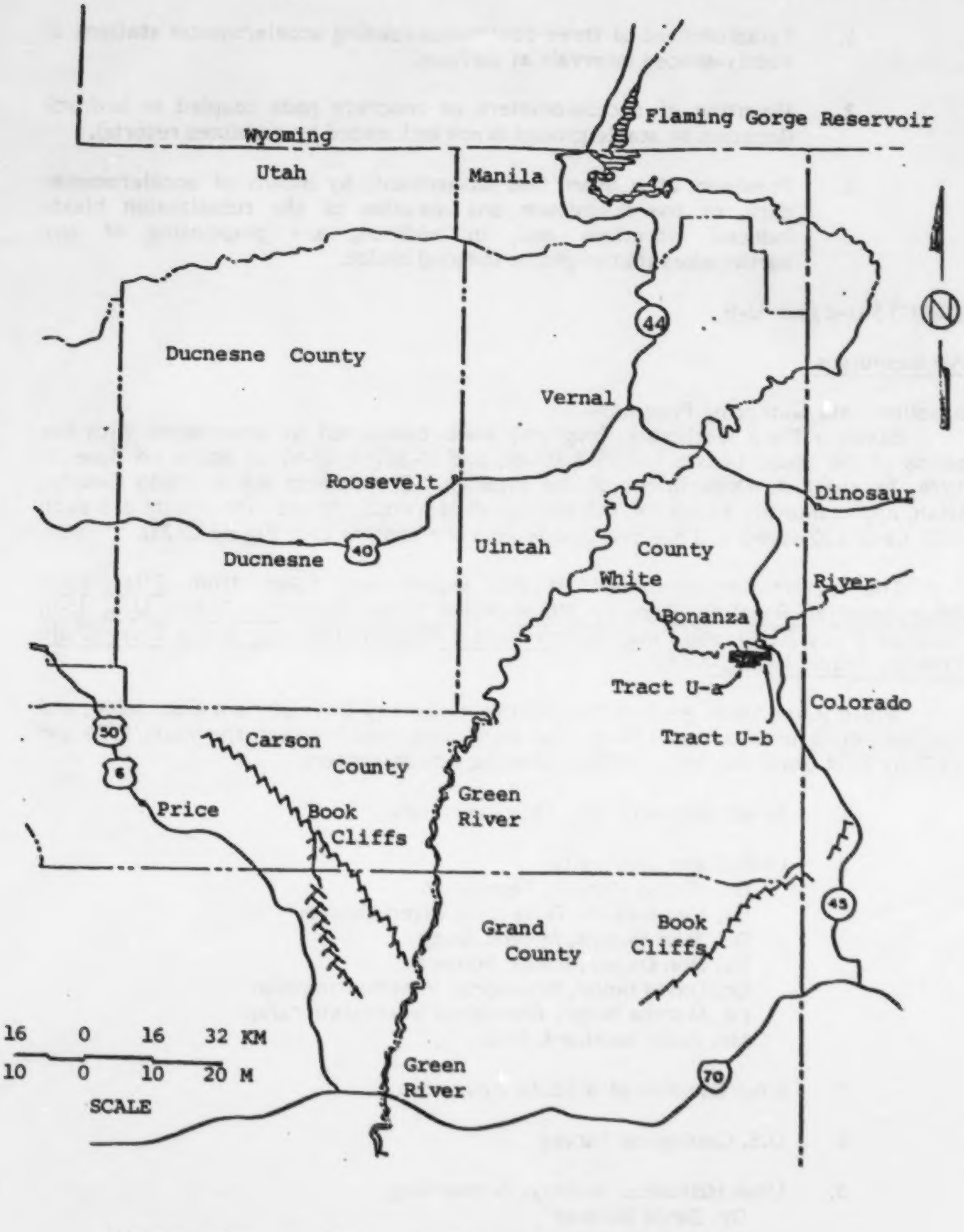
Flaming Gorge Reservoir
Wyoming
Utah
Manila
44
Ducnesne County
Vernal
Roosevelt
Dinosaur
40
Ducnesne
Uintah
County
White
River
Bonanza
Tract U-a
Colorado
Tract U-b
50
6
Carson
County
Price
Book
Cliffs
Green
River
45
Grand
County
Book
Cliffs
16 0 16 32 KM
10 0 10 20 M
SCALE
70
Green
River

Figure C-28. Location map for Tract U-a and U-b projects.

6. Brigham Young University, Paleontology
   Dr. Wade Miller

7. Fugro Inc., Geology

8. Richter and Associates, Seismicity

In the first year of baseline data gathering, eight monitoring stations were developed to sample air quality parameters in the area. The stations were situated so that every 13 km^2 (5 sq mi) was occupied by one monitor (Figure C-29.) The air quality and meteorological parameters measured are presented in Table C-26, the parameters measured at each air quality station are shown in Figure C-29.

Sulfur dioxide (SO_2) and hydrogen sulfide (H_2S) were measured by gas chromatography using a flame photometric detector. Carbon monoxide (CO) was also measured by gas chromatography utilizing a flame ionization detector after the catalytic conversion to carbon dioxide (CO_2). Total and nonmethane hydrocarbon (NMHC) were separated by gas chromatography and measured by flame ionization techniques. Ozone was monitored by chemiluminescence of NO with ozone, catalytic conversion of NOx to NO for similar chemiluminescent measurement, and subtraction of NO from NOx to give nitrogen dioxide (NO_2) (see Table C-26).

All major air quality instruments were calibrated quarterly and by secondary calibration standards (permeation tubes and compressed gas mixtures) after each malfunction. The secondary standards were in turn calibrated quarterly by EPA-prescribed wet chemical analysis procedures (32). The estimated accuracy of the methods and instruments used is presented in Table C-26.

From data gathered in the first year of baseline work, it was determined that certain monitoring programs were unnecessary and that certain corrections to the second year program were in order. The following items were terminated for the second year baseline program, with approval from the Area Oil Shale Supervisor:

1. Measurements on coefficient of haze,
2. Air quality monitoring (H_2S, SO_2, and suspended particulates) at Station A1,
3. SO_2, H_2S, suspended particulate, NO_2, HC, CO, and O_3 measurements at Station A2,
4. NO_2, HC, CO, and O_3 measurements at Station A3,
5. All air quality monitoring (H_2S, SO_2, and suspended particulates) at Station A5,
6. All air quality monitoring (H_2S, SO_2, and suspended particulates) at Station A8.

After the first year of baseline meteorological data gathering, certain adjustments were made to the monitoring program. Five of the 12 monitoring stations were shut down, and one new one was developed.

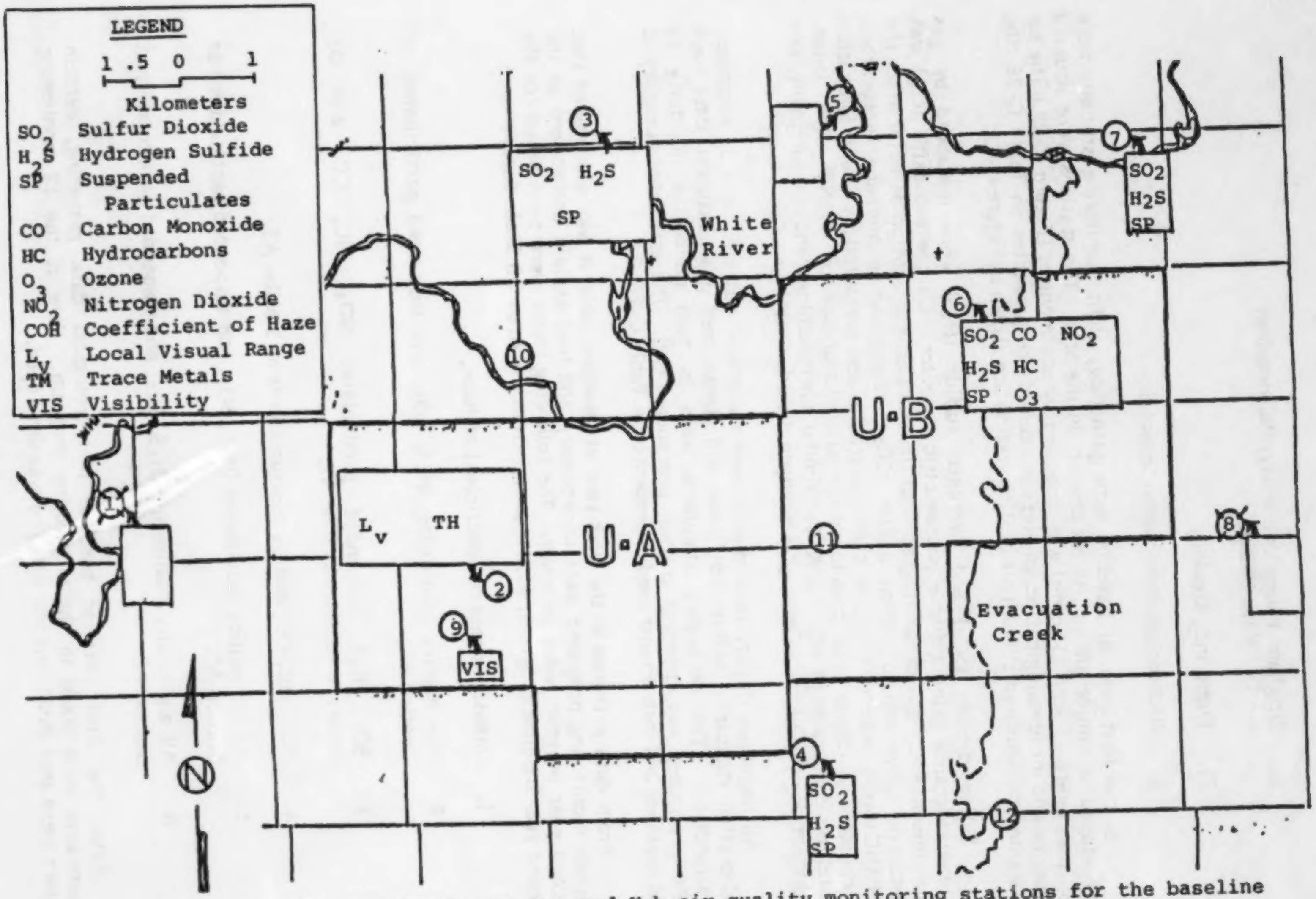
LEGEND
1 .5 0 1
Kilometers
SO2 Sulfur Dioxide
H2S Hydrogen Sulfide
SP Suspended Particulates
CO Carbon Monoxide
HC Hydrocarbons
O3 Ozone
NO2 Nitrogen Dioxide
COH Coefficient of Haze
Lv Local Visual Range
TM Trace Metals
VIS Visibility
N
1
2
3
SO2 H2S SP
4
SO2 H2S SP
5
6
SO2 CO NO2 H2S HC SP O3
7
SO2 H2S SP
8
9
VIS
10
11
12
Lv TH
U-A
U-B
White River
Evacuation Creek

Figure C-29. Location map for Tracts U-a and U-b air quality monitoring stations for the baseline data gathering programs.

TABLE C-26. AIR QUALITY PARAMETERS, MONITORING INSTRUMENTS, AND TOTAL ROOT-MEAN-SQUARED ACCURACY OF THE BASELINE AIR QUALITY PROGRAM FOR TRACTS U-a AND U-b

Parameters	Monitoring instruments	Total RMS accuracy
Sulfur dioxide	Tracor 270 HA sulfur analyzer--gas chromatography	± 7% or 4 ppb
Hydrogen sulfide	Tracor 270 HA sulfur analyzer--gas chromatography	± 12% or 8 ppb
Total sulfur	Tracor 270 HA sulfur analyzer--gas chromatography	
Nitrogen oxides (NO, NO_x, NO_2)	Monitor Labs Model 8440 NO_x analyzer-- chemiluminescence	± 6% or 0.01 ppm
NMHC		± 4% or 0.2 ppm
Hydrocarbons (Total Hydrocarbon, CA_4)	Beckman 6800 gas chromatograph flame ionization	± 3% or 0.1 ppm
Carbon monoxide	Beckman 6800 gas chromatograph--flame ionization	
Oxidants (O_3)	Monitor Labs 8410 ozone analyzer--chemiluminescence	± 5% or 0.01 ppm
Suspended particulates	General Metals Model 5000 HiVol w/constant flow control	± 1 ug/m^3
Wind speed	MRI Model 1022 anemometer MRI Model 1071 Mechanical weather station	± 2% or .25 m/s
Wind direction	MRI Model 1022 anemometer MRI Model 1071 Mechanical weather station	± 3°
Temperature	MRI Model 1071 Mechanical weather station	± 0.2° C
Wind variance	MRI Model 1022 and R.M. Young anemometer, and AeroVironment sigma meter	
Change in temperature	MRI Thermistors w/ R.M. Young shield	± 0.15° C
Dew point	Weather Measures Model H321S hydrograph	± 2° C

Surface meteorology was measured continuously at 12 air resources monitoring stations. The locations of these stations are illustrated in Figure C-29, together with the parameters measured at each site. The method used for each parameter measurement is presented in Table C-26.

Calibration of the equipment was made at the outset of the project and at least quarterly after that. Estimates of the accuracy obtained from the most common sensors are tabulated in Table C-26. It should be noted that site-specific factors such as the sensor location in relation to topographic features and sensor height contribute more to the data variability than do instrument variability.

Measurements of upper air meteorology were made by means of rawinsonde balloons launched from one of the established air quality monitoring stations at various times. The balloons recorded temperature, relative humidity, windspeed and direction. The balloons were launched twice every sixth day, within 1 hour after sunrise and at approximately 1400 MST. This schedule was altered when weather did not permit scheduled launching. Acoustic soundings were made continuously by a monostatic acoustic sounder, supplemented by a bistatic sounder at certain times of the year. Monostatic records reveal atmospheric structure, stability, temperature inversions, and thermal plumes up to a height of 1 km (.6 mi) above surface. Measurements were made from the lowest atmospheric level 0.6 m (.36 mi) to the 500 millibar (mb) pressure level (about 5,500 m or 18,000 ft above sea level).

After the first year of baseline data gathering, the upper air meteorology tests were terminated. All available data can be found in the text of References 30 and 31.

Precipitation--

Twelve precipitation monitoring gages were implemented on and around Tracts U-a and U-b in January of 1976, as directed by the Area Oil Shale Office. The location of these monitoring stations is presented in Figure C-30.

Standard-recording and continuous-recording weighing gages cammed to punch at 5-min intervals were used to monitor precipitation. Rain water samples were collected upwind, near the center, and downwind of the tracts by reconnaissance at the three locations using a plastic sheet and prepared bottles. Snow samples were collected in winter, and rain samples were taken in late spring, early fall, and during summer thunderstorms.

Two evaporation tanks with screened covers were also located in Tracts U-a and U-b. Water losses were recorded, and tanks were refilled twice a week.

Interim Monitoring Activities--

The interim monitoring program is that which has existed since the completion of the Tract U-a and U-b baseline data gathering program and which is still being implemented during the present lease suspension period. Information for this report has been taken from References 33, 34, and 35.

These reports have been prepared by the WRSP, Sunoco Energy Development Co., Sohio Natural Resources Co., and Phillips Petroleum Co.

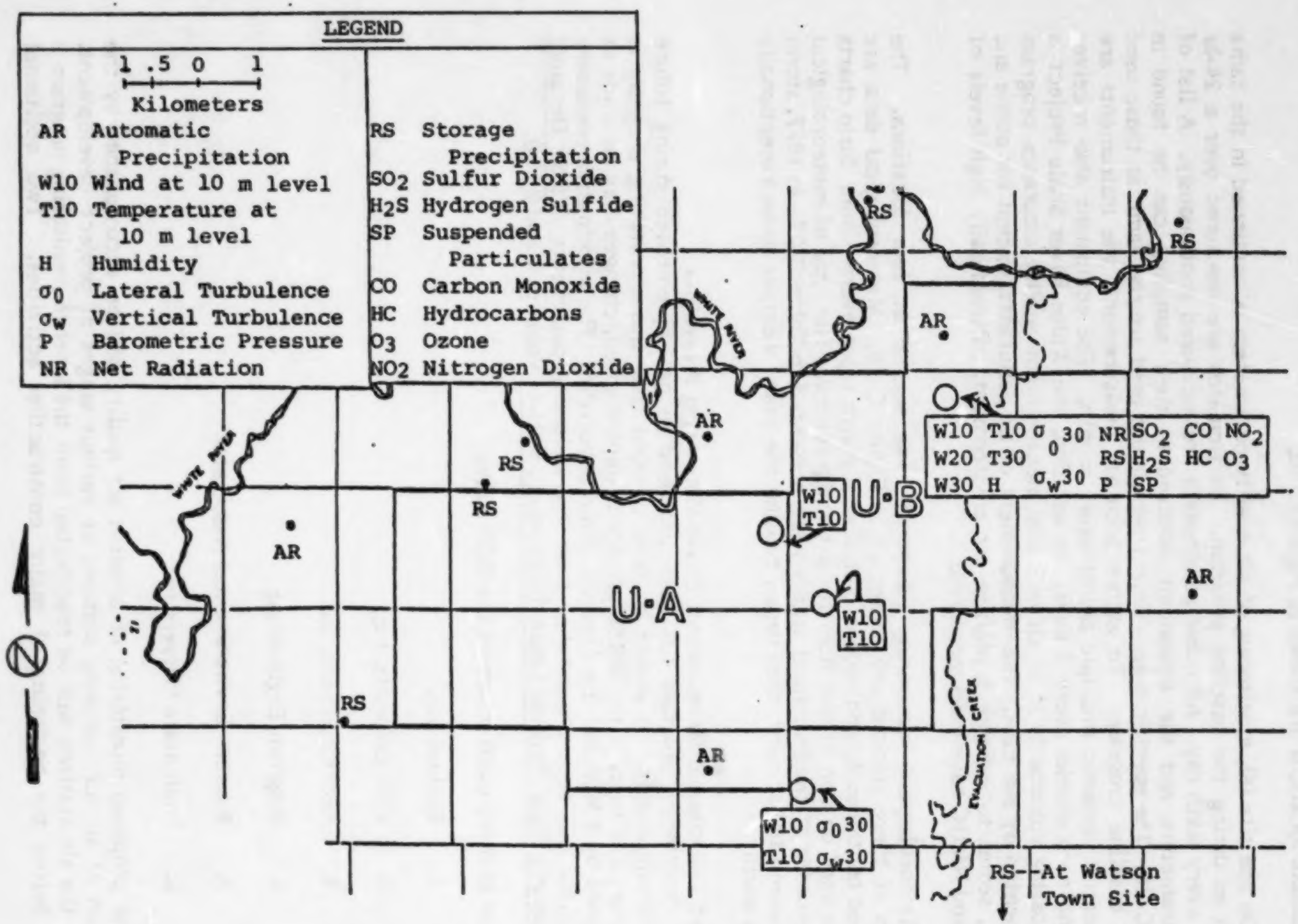
LEGEND
1 .5 0 1
Kilometers
AR Automatic Precipitation
W10 Wind at 10 m level
T10 Temperature at 10 m level
H Humidity
σ0 Lateral Turbulence
σw Vertical Turbulence
P Barometric Pressure
NR Net Radiation
RS Storage Precipitation
SO2 Sulfur Dioxide
H2S Hydrogen Sulfide
SP Suspended Particulates
CO Carbon Monoxide
HC Hydrocarbons
O3 Ozone
NO2 Nitrogen Dioxide
WHITE RIVER
WHITE RIVER
EVACUATION CREEK
U·A
U·B
AR
RS
W10 T10
W10 T10
W10 T10 σ0 30 NR SO2 CO NO2
W20 T30 RS H2S HC O3
W30 H σw 30 P SP
W10 σ0 30
T10 σw 30
RS--At Watson Town Site
N

Figure C-30. Location map for Tracts U-a and U-b interim air quality and meteorology monitoring stations.

The monitoring of ambient air quality parameters within Tracts U-a and U-b began at the conclusion of the baseline data gathering program in January 1977. At that time, operations were continued at four air monitoring stations. Their approximate locations are shown in Figure C-30.

On one site (6), monitoring of air quality parameters is continued in the same fashion as during the baseline program. Particulates are measured over a 24-hr period every sixth day. All other parameters are measured continuously. A list of the parameters and the equipment involved in their sampling can be found in Table C-26. The specific measurement techniques used are the same as those used in the baseline program. To assure accurate measurement, the instruments are recalibrated (dynamic multiple point) every month. The equipment also receives span and zero checks every 2 days. In addition, the White River Shale Project is participating voluntarily in an air pollution measurement quality assurance program implemented by the EPA. The measurement of all pollutants, except for ozone and NMHC, seems to indicate a pristine air environment. Periodically high levels of ozone and NMHC have been measured.

Meteorological monitoring equipment was set up at four locations. The settings of these stations are presented in Figure C-30. Meteorological data are collected continuously and recorded on digital punch tapes every 6 min. Strip charts are also used on two of the sites for a backup record. The type of meteorological data recorded at the individual stations are presented in Table C-27. In 1977, storm tracks were farther north than usual, causing the year's weather to be exceptionally dry and warm.

Proposed Commercial Development Phase Monitoring Program--

A monitoring program has been proposed to be implemented during future WRSP developments. It should be kept in mind that this monitoring program is preliminary and that, as the WRSP project is implemented, changes may be made as determined by WRSP and the Area Oil Shale Supervisor. The information necessary to complete this report was taken from the following document: WRSP Detailed Development Plan: Federal Lease Tracts U-a and U-b, Volumes 1 and 2 (36).

The primary contractors on the DDP were:

1. Bechtel Inc.
2. VTN Colorado, Inc.
3. AeroVironment, Inc.
4. Bingham Engineering
5. Western Environmental Associates
6. Utah State University

The proposed monitoring of ambient air quality will be accomplished by the activation of six air sampling stations at various stages of project development. Four of the six stations will be reactivated from the interim monitoring program 3 months before the beginning of major construction activities. Two additional

TABLE C-27. METEOROLOGICAL PARAMETERS MONITORED DURING THE LEASE SUSPENSION PERIOD

Parameter	Station			
	A4	A6	A11	A13
Meteorology:				
WS/WD - 10 m	X	X	X	X
WS/WD - 20 m		X		
WS/WD - 30 m		X		
T - 10 m	X	X	X	X
Δ T - 10-30 m		X		
σ_θ - 10 m	X			
σ_θ - 30 m		X		
σ_w - 10 m	X			
σ_w - 30 m		X		
Net solar radiation		X		
Dew point		X		
Relative humidity		X		
Barometric pressure		X		
Precipitation		X		

stations will be reactivated before commercial operation. It has been proposed that once all six stations have been reactivated, they remain in operation until discontinuation is agreed on by the WRSP and the Area Oil Shale Supervisor. The type of equipment to be used at each station is presented in Table C-28, together with the parameters to be measured by each monitoring station, the scheduling, and the monitoring frequency.

In addition to air quality and meteorology sampling stations, source sampling access points will be located at all points of possible significant pollutant emissions to the atmosphere. These sampling ports will allow for compliance testing and validation of atmospheric model results with regard to future project phases.

All instruments will be calibrated at least once every 3 months to ensure their continuing accuracy. In addition, as data are being extracted from the analog records, they will be scanned for anomalous readings. In the monitoring program, all instruments will be inspected in situ at least twice a week, and a record will be kept of maintenance and of any malfunctions. Corrective actions will be logged.

TABLE C-28. AIR QUALITY AND METEOROLOGICAL PARAMETERS, INSTRUMENTATION, SAMPLING FREQUENCY, AND SCHEDULES OF PROPOSED COMMERCIAL PHASE RESOURCE MONITORING PROGRAM FOR TRACTS U-a AND U-b

Air resource parameters	Monitoring instrumentation	Monitoring stations	Monitoring schedule[a]	Monitoring frequency[a]
Wind speed and direction	MRI Model 1022	A-6 (10 and 30 m) A-3 (10 m) A-7 (10 m) A-11 (10 m)	1 2 2 1	C
Wind speed, direction, and temperature	MRI Model 1071 mechanical weather station	A-2, A-4 A-13	1, 1 1	C
Wind variance	MRI Model 1022/R.M. Young and AeroVironment sigma meter	A-6 (30 m)	1	C
Temperature and lapse rate	MRI Thermistors w/R.M. Young shield	A-6 (10 and 30 m)	1	C
Dew point	EG&G Model 880 hygrometer	A-6	1	C
Suspended particulates	General Metals Model 5000 HiVol Constant Flow Control	A-2, A-3, A-6, A-11	1, 2 1, 1	A
Sulfur dioxide	Tracor 270 11A sulfur analyzer--gas chromatography	A-3, A-6 A-7, A-11	2, 1 2, 1	C
Nitrogen oxides	Monitor Labs Model 8440 NO_x analyzer chemiluminescence	A-3, A-6	2, 1	C
Hydrocarbons	Beckman 6800 gas chromatograph--flame ionization	A-3, A-6	2, 1	C
Carbon monoxide	Beckman 6800 gas chromatograph--flame ionization	A-3, A-6	2, 1	C
Oxidants	Monitor Labs 8410, ozone analyzer--photoluminescence	A-3, A-6	2, 1	C
Precipitation	Fisher-Porter Automatic Rain Gauge Series 35 B 1558	P1, A-8, Plant Site S-9, A-2, S-12	1, 1, 1, 1, 1, 1	C

[a] 1: Initiated three months before construction and continuing through commercial operation.
2: During commercial operation.
C: Continuous.
A: One 24-hr sample each 6 calendar days.

Water Resources

Baseline Data Gathering Program--

The programs for the development of baseline hydrological data were conducted during the same time period and by the same contractors who performed the baseline air quality and meteorology data gathering programs. The information for this baseline surface and groundwater report has been drawn from the U-a, U-b First Year Environmental Baseline Report (30) and the Final Environmental Baseline Report (31).

Surface water--Surface water in the Tract U-a and U-b area was sampled from seven monitoring stations set up along various perennial and annual watercourses. The approximate locations of these stations are illustrated in Figure C-31.

Each surface water monitoring station was equipped with a stilling well and equipment to record specific conductance, temperature, and flow. Bottom sediment samples and water quality samples were taken by VTN and the USGS quarterly and semiannually. The USGS-Salt Lake City analyzed all water quality samples, processed the continuous punched-tape records of specific conductance, temperature, and flow, and developed the flow-rating curves. A list of the water quality parameters measured is presented in Table C-29. Surface water flow was measured throughout the year, or as directed by the Area Oil Shale Office, and the water monitoring stations were checked at least twice a month by Voorheis-Trindle-Nelson and USGS.

Groundwater--Four test wells were sunk at the outset of the program to locate aquifers and study stratigraphy and oil shale properties. As a result of the test wells, 20 wells were sunk at various locations for observation and pumping. At each test well rotary air drilling was used to collect 8.9 cm (3.5 in.) cores from the ground to a depth of 122 m (400 ft) below the Mahogany Zone. At maximum intervals of 9.2 m (30 ft), the discharge fluids were measured for temperature, specific conductance, and flow quantities. Additional tests were run consisting of: (a) gamma ray, (b) gamma-gamma density, (c) neutron, (d) neutron epithermal neutron, (e) flow, (f) temperature, (g) caliper, (h) SP, and (i) resistivity. Each test well was developed as an aquifer test site and suited with a pumping well and two up-dip observation wells 15 m (50 ft) and 40 m (131 ft) from the test hole. Also, water level sensing devices and punch tape recorders, set to punch at 15-min intervals, were used for continuous monitoring. At the 20 observation wells, water levels were measured with steel tapes and electric probes. Groundwater chemistry was determined from water samples drawn once every 6 months. Thirteen alluvial wells were developed to measure water levels, subsurface water migration, and groundwater quality. Where the alluvium contained water, samples were taken and analyzed monthly. Seven deep aquifer wells were monitored for the same purposes. These and other wells have been logged quarterly, using a combination of gamma ray and neutron tools. The locations of these wells can be found in Figure C-31.

In January 1975, 12 additional alluvial wells were developed as directed by the Area Oil Shale Office to assist in the vertical gradient moisture monitoring at proposed processed shale disposal sites.

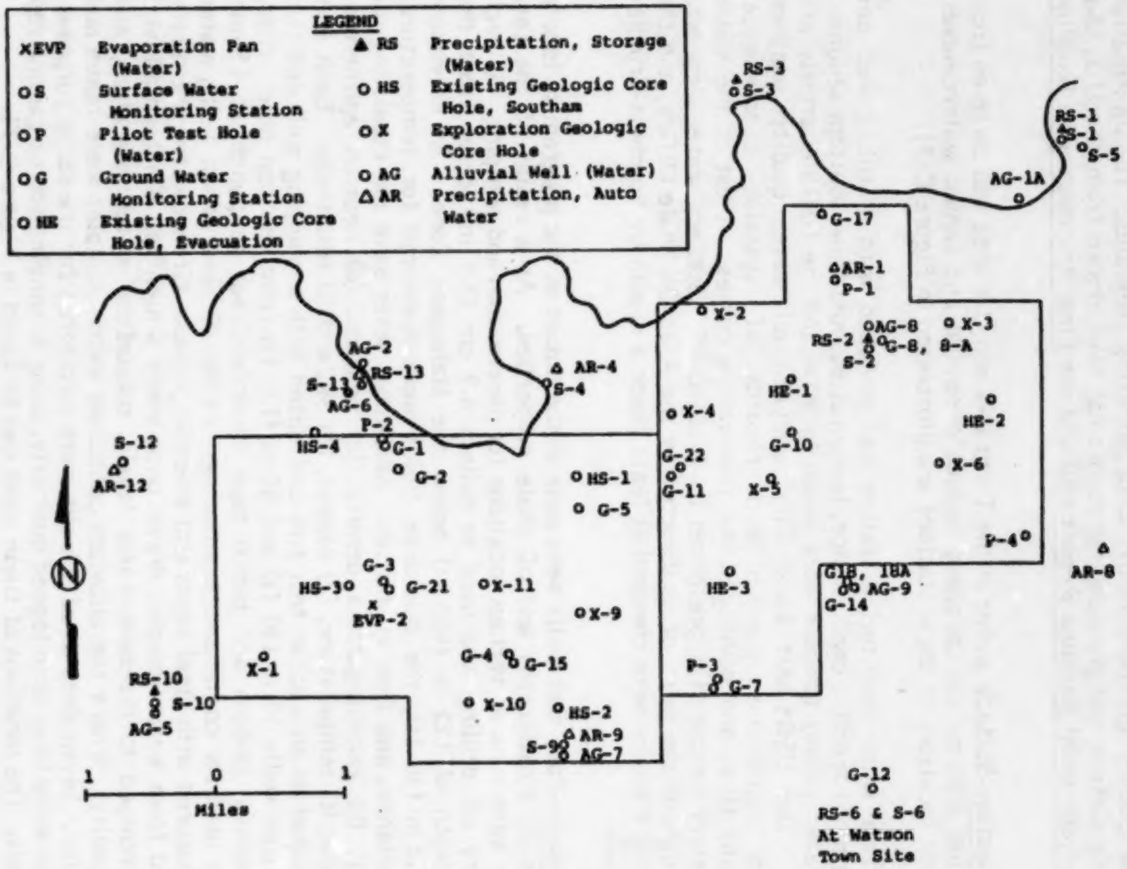
LEGEND
X EVP Evaporation Pan (Water)
O S Surface Water Monitoring Station
O P Pilot Test Hole (Water)
O G Ground Water Monitoring Station
O HE Existing Geologic Core Hole, Evacuation
▲ RS Precipitation, Storage (Water)
O HS Existing Geologic Core Hole, Southam
O X Exploration Geologic Core Hole
O AG Alluvial Well (Water)
△ AR Precipitation, Auto Water
RS-3
S-3
RS-1
S-1
S-5
AG-1A
G-17
AR-1
P-1
X-2
AG-8
X-3
RS-2
G-8, 8-A
S-2
AG-2
RS-13
AR-4
S-4
S-11
AG-6
HE-1
X-4
HE-2
P-2
G-1
G-10
S-12
HS-4
G-22
X-6
AR-12
G-2
HS-1
G-11
X-5
G-5
P-4
AR-8
G-3
HE-3
G1B, 18A
HS-3
G-21
X-11
AG-9
G-14
EVP-2
X-9
G-4
G-15
X-1
P-3
G-7
RS-10
S-10
X-10
HS-2
AG-5
AR-9
S-9
AG-7
1
0
1
Miles
G-12
RS-6 & S-6
At Watson
Town Site
N

Figure C-31. Water and geologic resources baseline monitoring stations.

TABLE C-29. WATER QUALITY PARAMETERS MEASURED IN BASELINE, SURFACE AND GROUNDWATER DATA GATHERING PROGRAM FOR TRACTS U-a AND U-b

	Schedule					
	Baseline program		Interim program		Proposed program	
Parameter	Surface	Groundwater	Surface	Groundwater	Surface	Groundwater
Calcium	Q[a]	SD,XA	Q	SD,XA	M	SD,XA
Magnesium	Q	SD,XA	Q	SD,XA	M	SD,XA
Sodium	Q	SD,SA	Q	SD,SA	M	SD,SA
Potassium	Q	SD,XA	Q	SD,XA	M	SD,XA
Chloride	Q	SD,XA	Q	SD,XA	M	SD,XA
Sulfate	Q	SD,XA	Q	SD,XA	M	SD,XA
Bicarbonate	Q	SD,XA	Q	SD,XA	M	SD,XA
Carbonate	Q	SD,XA	Q	SD,XA	M	SD,XA
Alkalinity	Q	SD,XA	Q	SD,XA	M	SD,XA
Hardness	Q	SD,XA	Q	SD,XA	M	SD,XA
Fluoride	Q	SD,XA	Q	SD,XA	M	SD,XA
Silica	Q	SD,XA	Q	SD,XA	M	SD,XA
Iron	Q	SD,XA	Q	SD,XA	M	SD,XA
Aluminum	Q	SD,XA	Q	SD,XA	M	SD,XA
Boron	Q	SD,XA	Q	SD,XA	M	SD,XA
Lithium	Q	SD,XA	Q	SD,XA	M	SD,XA
Strontium	Q	SD,XA	Q	SD,XA	M	SD,XA
Magnesium	Q	SD,XA	Q	SD,XA	M	SD,XA
Phosphate	Q	SD,XA	Q	SD,XA	M	SD,XA
Total phosphorus	Q	SD,XA	Q	SD,XA	M	SD,XA
Nitrate	Q	SD,XA	Q	SD,XA	M	SD,XA
Nitrite	Q	SD,XA	Q	SD,XA	M	SD,XA
Ammonia	Q	SD,XA	Q	SD,XA	M	SD,XA
Total Kjedahl nitrogen	Q	SD,XA	Q	SD,SA	M	SD,SA
Chemical oxygen demand	Q	SD,SA	Q	SD,SA	M	SD,SA
Chlorophyll A	Q	SD,SA	Q	SD,SA	M	SD,SA
Chlorophyll B	Q	SD,SA	Q	SD,SA	M	SD,SA
Color	Q	SD,SA	Q	SD,SA	M	SD,SA
Turbidity	Q	SD,SA	Q	SD,SA	M	SD,SA
Dissolved solids	Q	SD,XA	Q	SD,XA	M	SD,XA
Arsenic	S	SD,XA	Q	SD,XA	M	SD,XA
Cadmium	S	SD,XA	Q	SD,XA	M	SD,XA
Chromium	S	SD,XA	Q	SD,XA	M	SD,XA
Copper	S	SD,XA	Q	SD,XA	M	SD,XA
Mercury	S	SD,XA	Q	SD,XA	M	SD,XA
Molybdenum	S	SD,XA	Q	SD,XA	M	SD,XA
Selenium	S	SD,XA	Q	SD,XA	M	SD,XA
Vanadium	S	SD,XA	Q	SD,XA	M	SD,XA
Zinc	S	SD,XA	Q	SD,XA	M	SD,XA
Barium	S	SD,XA	Q	SD,XA	M	SD,XA
Sulfide	S	SD,XA	Q	SD,XA	M	SD,XA
Bromide	S	SD,XA	Q	SD,XA	M	SD,XA
Lead	S	SD,XA	Q	SD,XA	M	SD,XA
Detergents[b]	S		Q		M	
Organic carbon	S	SD,XA	Q	SD,XA	M	SD,XA
Pesticides	S		Q		M	
Phenols	S		Q		M	
Gross alpha, gross beta[c]	S	SD,XA	Q	SD,XA	M	SD,X

[a] M = Monthly X = Seasonally
Q = Quarterly A = Alluvial aquifer
S = Semiannually D = Deep oil shale aquifer

[b] Not included in WRSP Program.

[c] If gross alpha activity is measured at greater than 4 pci/l, then analysis for radium 226 and for natural uranium will be done. If gross beta activity is greater than 100 pci/l, then analysis for Sr^{90} and Ce^{137} will be done.

Interim Monitoring Activities--

The interim surface and groundwater monitoring program was begun in 1977 and is continuing with termination of the lease suspension and commencement of the commercial development phase. The primary contractors on this program are the same as those identified in the discussion of the baseline air quality and meterorology data gathering program. The sources of information are the Progress Report: Environmental Programs, Work Plan Lease Suspension Period, and WRSP Detailed Development Plan (33-36).

The Interim program has been designed to be used in conjunction with USGS studies presently being conducted in the areas of Tracts U-a and U-b.

Surface water--The USGS and WRSP water monitoring teams set up a combined total of 16 samplers throughout Tracts U-a and U-b along the paths of pertinent drainage courses. Stream flow is measured by WRSP continuously at two sites, and at peak and low flow at one other site. The digital recorder tapes are removed and processed monthly. Stream flow is monitored by USGS continuously at five locations through the area.

Suspended sediments were intended to be sampled continuously at two WRSP sites; however, severe icing caused one sampler to be shut down from December 18, 1976 to March 31, 1977. It was restarted to draw four samples a day. Manual suspended sediment measurements were taken at least monthly to ensure proper calibration of the instruments. Because of lack of major snowmelt, no sampling beyond the original schedule was performed. Sediment is monitored by the USGS at four locations. Automatic samplers and two-bottle, single-stage samplers are in use.

Water quality samples are drawn at one site by WRSP on a quarterly basis. Dissolved oxygen, temperature, pH, and conductivity are measured in the field at the time samples are collected. The constituents are analyzed according to the schedule presented in Table C-29. Water quality samples are collected by the USGS at three sites, also on a quarterly basis. The samples are analyzed according to the schedule presented in Table C-29. Temperature and conductivity are measured continuously by WRSP at one site. Both probes are checked and calibrated regularly, and the digital recorder tapes are pulled and processed monthly.

Groundwater--The WRSP and USGS have placed wells at 12 locations around the areas of Tracts U-a and U-b for the purpose of monitoring water levels in the local deep aquifers. The locations of these wells are shown in Figure C-31.

Water levels are continuously monitored by the USGS at three wells, and time-activated digital punch recorders record the level hourly at all four wells and, to assure accuracy, one well is checked manually by WRSP monthly. In addition, manual-level readings are taken by WRSP at eight additional wells. These measurements are taken twice a year, in January and July—times of the year that correspond to highest and lowest levels.

The water levels seem to be consistent with observations during baseline studies for all wells except one. The condition at this well seems anomalous, and no explanation is presently available.

Eight wells are developed in five different alluvial drainage areas by the WRSP and USGS. Five additional wells are available for water quality monitoring if the conductivity of water has been found to be 20 percent to the extreme side of maximum or minimum value found in prior, comparable time periods. The locations of these wells are shown in Figure C-31.

Water samples were drawn from the eight original wells on a quarterly basis through December 1976 and analyzed according to the program presented in Table C-29. As of January 1977, these quarterly-drawn samples are measured for water level, temperature, and conductivity. Water quality samples were taken only during high flow of 1977 at five sites. These samples were analyzed according to the schedule in Table C-29. Water level, temperature, and conductivity analyses have been resumed on a monthly basis during snowmelt and thunderstorm seasons.

A slight decline in static water level was noticed in 1977, probably because of low annual precipitation and consequent low recharge capabilities.

Proposed Commercial Development Phase Monitoring Program—

The proposed surface and groundwater monitoring program to be conducted during Tract U-a and Tract U-b commercial development has been outlined in the WRSP Detailed Development Plan (36).

The water monitoring program described here will continue until Phase II construction has been underway for approximately 18 months. The program will be reassessed at that time on the basis of future development activities and analyses of Utah processed shale and processed shale leachate.

Surface water--Surface water monitoring will begin immediately after the end of the interim monitoring program. The exact schedules have not yet been determined. Seven recording stations are proposed to be situated along main drainage courses throughout the tracts. The equipment will be the same as was used during baseline data gathering. Continuous streamflow records will be taken at all seven stations. Three of the seven stations are expected to experience zero flow rates for most of the year, and these points will be sampled for water quality manually, as necessary. Temperature and specific conductance will be monitored continuously and automatically at the four perennial streams and at the three annual streams when flow exists. Four of the seven stations will be sampled monthly, and an analysis of the water quality parameters in Table C-29 will be carried out.

Monitoring of water in the retention dam located downstream of the processed shale disposal site will be carried out when there is standing water. Water depth will be measured quarterly, and an automatic level recorder may be installed. Water quality will be measured quarterly, using the same parameter list as for stream water analyses (Table C-29). The same monitoring will also be used for any new ponds that may form during the life of the processed shale disposal system.

All surface water samples will be collected using standard field equipment and techniques. All parameters will be determined according to procedures detailed in Standard Methods for the Examination of Water and Wastewater (37), or according to methods approved by the Area Oil Shale Supervisor, where appropriate.

Groundwater--Groundwater quality will be monitored quarterly (if water is present) at 11 alluvial wells and semiannually at five deep aquifer wells. These wells are the same ones used in the baseline monitoring program. Depth to water will also be measured at nine of the 16 wells. Water samples will be drawn from each well using a pump or, in the case of small diameter wells, a boiler or thief sampler. Water depth measurements will be made using a steel-type electric probe or continuous water level recorder.

Semiannual samples will be collected in May-June and November-December. Quarterly samples will be collected during February-March and August-September. The water quality parameters to be tested are listed in Table C-29. Water sample collection and treatment will follow methods described in Techniques of Water-Resources Investigations of the U.S. Geological Survey (38).

In addition to analyses of water drawn from deep aquifer and alluvial wells, analyses will be performed on water drawn from shallow wells to be drilled adjacent to processed shale stockpiles. This test should provide information on any shallow aquifer contamination as rapidly as possible.

Biological Resources

Baseline Data Gathering Program--

The baseline biological resource data gathering program was conducted from 1974 to 1976. The major contractors on the project have been outlined in the baseline air quality program. All information generated by the baseline biological resource program was published in the First Year Environmental Baseline Report (30), and the Final Environmental Baseline Report (31). All program procedures and analytical methods have been taken from these publications.

Vegetation--Vegetation in the Tract U-a and U-b area was sampled in 400 plots. Within each of the four vegetation types existing in the local environment, five sites were picked, making a total of 20 sites. Within each of the 20 sites, 20 plots were developed, thus giving a total of 400 plots. A map showing the location of the vegetation study areas within each vegetation type is shown in Figure C-32. Within each plot, four plant attributes were established by two-man teams. These attributes were species, height, cover, and density. The sampling program was carried out in the spring to estimate the characteristics of species maturing in June, and in the fall to estimate the characteristics of late-summer maturing species (perennials).

Field plot data were analyzed statistically to determine a 90-percent confidence interval about the means and the necessary sample size (number of plots) required to estimate within 25 percent of the true mean with a 90-percent statistical probability for each attribute measured for each species. The sampling procedures were basically the same in the second year of sampling, except for the following changes:

1. The number of plots analyzed in June 1976 were doubled from 1975.
2. Seedlings of the major shrub and tree species were observed and recorded separately to measure reproduction.

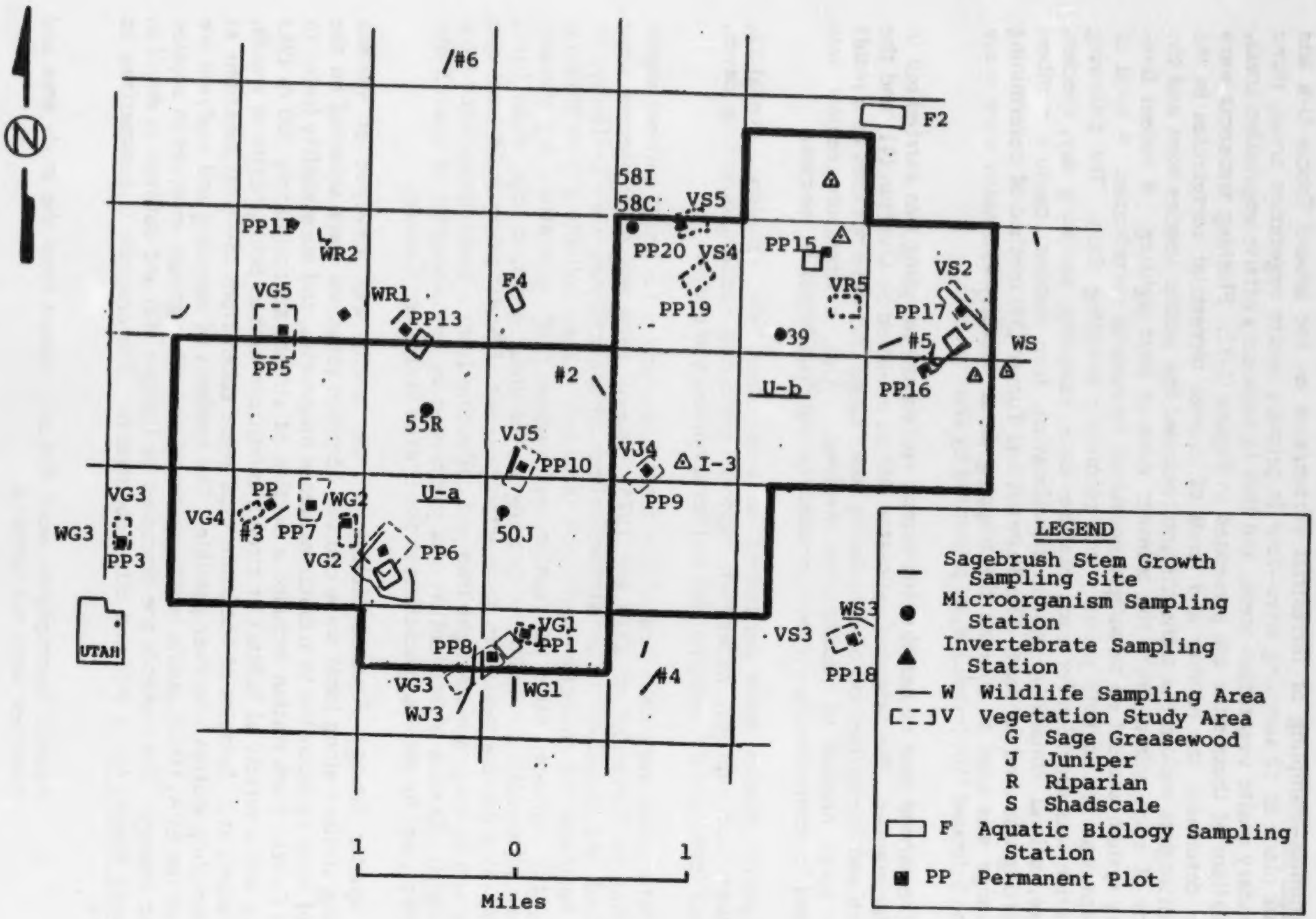
N
#6
F2
58I
58C
VS5
PP20
VS4
PP15
PP11
WR2
WR1
PP13
F4
VG5
PP5
PP19
VR5
39
VS2
PP17
#5
WS
PP16
U-b
#2
55R
VJ5
PP10
VJ4
I-3
PP9
PP
VG4
#3
PP7
WG2
VG2
PP6
U-a
50J
VG3
WG3
PP3
UTAH
VG1
PP1
PP8
VG3
WJ3
WG1
#4
VS3
WS3
PP18
1
0
1
Miles
LEGEND
Sagebrush Stem Growth Sampling Site
Microorganism Sampling Station
Invertebrate Sampling Station
W Wildlife Sampling Area
V Vegetation Study Area
G Sage Greasewood
J Juniper
R Riparian
S Shadscale
F Aquatic Biology Sampling Station
PP Permanent Plot

Figure C-32. Location map for Tract U-a and U-b biological resource sampling sites.

Animals--Sampling of terrestrial vertebrates on and around Tracts U-a and U-b took place at 12 sampling sites--four in primary onsite vegetation areas, three in secondary onsite vegetation areas, and five in secondary offsite vegetation areas. The locations of these sites are presented in Figure C-32. Flushing transects were used to determine the number and kinds of diurnal terrestrial vertebrates in the area. Biologists walked the transects and recorded the animal species seen and the distance of each animal from the transect time at first sighting. A rodent live-trapping system was set up to sample nocturnal terrestrial vertebrates. A total of 240 traps was set on both primary and secondary sampling sites. The following information was recorded for each capture: date, sampling, sampling day, species, sex, age, animal condition, animal identification, trap number, capture number. Mist netting was used for bats. The Jennrich and Turner (39) method of determining home range was used to analyze the trapping data. Density estimates were made with the Schnabel (40) technique, as presented by Overton (41).

The second year of baseline terrestrial vertebrate sampling was carried out in a similar manner. The Schnabel estimator (40) as modified by Overton (41) and the Jennrich and Turner method of calculating home range (39) were not used as a result of the large number of assumptions involved. Also, a literature review was employed to determine the presence or absence and distribution of species.

Special studies were performed on mule deer, elk, antelope, predators, amphibians and reptiles, waterfowl, raptors, cottontail rabbits, mourning doves, livestock (cows and domestic horses) and feral horses, and beaver.

Arthropods were collected on the tract and along a 1.6 km (1 mi) perimeter from May to September of 1974 and 1975. During 1975 and 1976, species were identified and classified. Quantitative collection and analyses were performed in 1976. Basically, the collection techniques included: (a) net collecting from flowers, leaves, soil surface, etc.; (b) routine net sweeping of vegetation; (c) malaise trapping; (d) searching in hiding or dwelling places under rocks, in logs, under bark, etc.; (e) using Berlese funnels to drive arthropods out of "duff" taken under trees and shrubs; and (f) using a black light trap and collecting from a sheet illuminated by a black light. Species identification was performed by entomologists of Utah State University, and by various specialists in the United States and Canada.

Aquatic biology--Aquatic biology on the tracts was surveyed at various sampling stations along local watercourses. Station locations were selected on the basis of their relationship to tributaries, lease boundaries, and accessibility (refer to Figure C-32). Each station included a section of stream approximately 300 m (985 ft) long and a variety of habitat or stream conditions such as pools, riffles or rapids, backwaters, etc. Samples of the same type were taken from identical locations at each sampling station wherever possible. The methods of sampling and analyses are those of the EPA, USGS, public health agencies, and other groups involved in applied aquatic biology. The methods are discussed by Usinger (42) and outlined in detail in Quarterly Report No. 4 (43) and other documents. The program is summarized as follows:

1. Aquatic macrophytes were virtually absent from the study area and therefore were not sampled.

2. Floating artificial substrates were used for collecting periphyton. One sample strip from each periphyton collection was preserved in formalin. The accumulated growth was scraped into the preservative from the sample strip with a rubber policeman. The sample jar was closed and agitated violently to disperse algal cells into the preservative. Aliquots were placed in a Sedgwick Rafter cell, and algal cells were counted in accordance with Standard Methods (37).

3. Plankton were not sampled for chlorophyll. Chlorophyll determinations were conducted in the surface water study.

4. Captured fish were identified, fin clipped, and released in 1976, as permitted by the Utah Division of Wildlife Resources. Some of the standard identification guides employed were Smith (44), Patrick and Reimer (45), and Weber (46). A Zeiss 32-x 1000 x phase contrast microscope was used.

Microbiology--The microbiological activity of the soil in the Tract U-a and U-b area was determined by analyzing soil samples taken from four sample holes, one in each vegetation area. Generally, the cores were taken in three stages down to 50 cm (20 in.). The locations of these sampling sites are to be found in Figure C-32. Each sample was ground in the laboratory and particles larger than 3 mm (0.12 in.) in diameter were removed. The sample was then stored at 4°C (40°F) until examined. The numbers of bacteria, streptomycetes, and fungi in the soils were determined by standard microbiological plating methods. Proteolytic activity was based on a protein (gelatin) hydrolysis by the soil enzyme. The total dehydrogenase activity was measured and defined as the ability of the soil biota to reduce triphenyltetrazolium chloride to the respective formazan. Soil respiration was measured by its CO_2 release, a process dependent on soil moisture conditions and the soil water potential measurements (i.e., measurement of available water, not total water content). ATP measurement (adenosine triphosphate) was based on the luciferin-luciferase reaction. Nitrogen fixation was determined with a gas chromatograph by the acetylene reduction method. The organic carbon content was determined by digestion of a soil sample with potassium dichromate. Ammonium, nitrate, and total nitrogen contents were determined by using appropriate Kjeldahl digestion systems and spectrophotometry.

Interim Monitoring Program--

The interim biological resource program for Tract U-a and U-b has been conducted since the conclusion of baseline studies in 1976. The interim program involves work on vegetation and terrestrial vertebrates. Data from USGS Water Resources Division aquatic biology monitoring program, the Utah Division of Wildlife Resources, and the Bureau of Land Management programs were incorporated when applicable. The main source of information on the interim program was the Progress Report: Environmental Programs 1977, WRSP (34) and the Work Plan: Lease Suspension Period (35).

Vegetation--Dr. Cyrus McKell is under contract with WRSP to conduct the vegetation monitoring program. During the monitoring program, plant samples are taken, and visual observation is pursued to accomplish the following: (a) measure productivity of annual plant species, (b) measure growth of dominant shrub, (c) measure percent of stems browsed on shrubs measured in (b); (d) observe seed production, seedling establishment, animal utilization, unusual buildup of insects or plant disease, or early seasonal dormancy.

At the peak of annual growth in the spring (June) annual species are clipped from approximately 200 0.5-m^2 (5.4 sq ft) plots and analyzed. In the fall (September -October) the current year's stem growth of the dominant shrub is measured in a paired plot arrangement along three transects along the zone of influence of the industrial site and in three transects in areas surrounding that site. During both these times (spring and fall) visual reconnaissance is conducted to observe reproduction, plant growth, vigor, and any excess animal utilization.

Animals--Bio Resources, Inc. was contracted to perform terrestrial vertebrate studies on Tract U-a and U-b beginning in December 1976 and ending December 1977. During that time, an attempt was made to establish five criteria. Those criteria were: (a) species inventory, (b) species distribution within habitat types, (c) species distribution within seasons of the year, (d) species abundance and density, (e) ecological relationships of vertebrates to their biotic and abiotic environment.

Two vertebrate sampling sites were placed on each of the prominent vegetation areas to study spatial distribution. To study temporal distribution, vertebrates were sampled in February, April, June, and August. To determine abundance and density, techniques particular to the different vertebrates were carried out at each sampling site. To establish an inventory, vertebrate identifications were carried out during each sampling period. The various techniques of sampling for each vertebrate type are listed below.

Mammals:	flushing transects, trapping, mist netting and large mammal aerial survey
Birds:	flushing transects
Reptiles:	flushing transects

During this interim monitoring program three hypotheses were tested: (a) mammal populations have reached a peak and will decline, (b) bird populations are in a downward trend and will continue to decline, and (c) reptile populations will remain stable. It was found that temporal and spatial distribution is affected by climate and that these changes are hence not long-term.

Aquatic biology—WRSP is not conducting any studies on aquatic biology during the interim period, but it is following the progress of an ongoing USGS study in the area.

Proposed Commercial Development Phase Monitoring Program--

The monitoring program prepared for future Tracts U-a and U-b commercial development is outlined in the WRSP Detailed Development Plan (36). All information necessary to complete this summary has been extracted from the DDP.

During the 2-year baseline program, relevant data were gathered to confirm which biological parameters were the most reliable indicators of the baseline biological conditions in the Tract U-a and U-b area. Those indicators that illustrate low variability or high correlation with other ecological factors will be standards against which to measure change.

The field program as proposed will have a series of vegetation plots, wildlife transects, and trapping grids against which to measure these indicator species. The field monitoring program itself will follow much the same line of the baseline program. An estimate of the appropriate parameters to be measured and the methods of sampling to be utilized is presented in Table C-30.

The WRSP will propose a system of data management and report format acceptable to the AOSS. Threshold values will be developed to indicate points of biological stress, beyond which significant deterioration of the local environment will exist. This will be done in recognition of the natural variability in even the most representative parameters.

Any changes brought about in the local ecology during plant operation will be evaluated in the following manner:

- Data from each station will be compared to the corresponding baseline data collected for that station in 1974-1976 to permit a statistical comparison of season-to-season or year-to-year changes.
- Data from each station will be compared to provide a "between sample" control and assessment of any differential change.
- Data on the growth rates and any evidence of leaf necrosis in sensitive species will be correlated to pollutant or emission concentrations predicted by the air dispersion model. Results will be compared between plots to detect changes at difference directions and distances from the emission source center.
- Browse utilization transects will be established in various locations to determine changes in grazing pressure as a result of displacement and enhancement procedures.
- Samples of plant tissue will be analyzed to demonstrate possible accumulation of toxic materials.
- Soil samples from representative localities will be analyzed and correlated with known meteorological conditions to demonstrate any project-related reduction in microbiological activity.

Solid Waste Disposal, Revegetation

Baseline Data Gathering Programs--

The gathering of baseline data on various aspects of revegetation has been accomplished at the Utah State University Agricultural Experiment Station. The head of the various projects was C. M. McKell, Professor of Range Management.

Various aspects of the revegetation concept have been evaluated. Some of those concepts are: (a) use of native adapted plant species, (b) transplanting of bare root and container-grown plants, (c) soil surface shaping, (d) soil surface stabilization, (e) limited use of topsoil, (f) minimal fertilization; and (g) temporary supplemental irrigation for salinity control and plant survival. In addition, studies have been performed to determine the most effective methods of naturally

TABLE C-30. SUMMARY OF PARAMETERS TO BE MEASURED FOR THE PROPOSED COMMERCIAL DEVELOPMENT OF TRACTS U-a AND U-b

Item to be measured	Parameter	Sampling plan
Vegetation	Species, density, height, cover, litter, productivity	100 samples (4 m^2 each) for each of four vegetation types
Birds	Species, number of individuals, age and sex, habitat	Three Emlen transects for each of the four vegetation types for a total of 24 transects/year
Rodents	Species, numbers, sex, age, body condition, habitat type, time of year, trap location	One trap grid of 144 traps for each of the four vegetation types
Small Game Species	Species, numbers, sex, location	Three flushing transects for each of the four vegetation types for a total of 24 transects per year
Big Game Species	Species, numbers, sex, age, location	Standardized aerial transects
Microorganisms	ATP concentrations, dehydrogenase activity, respiratory rate, soil moisture	Three soil samples of the top 10 cm from each vegetation type, as in baseline survey, sampled before, during, and after spring and fall rains

revegetating processed oil shale in the wild environment. All of the baseline revegetation programs have been summarized in the following documents: Achieving Effective Revegetation of Disposed Processed Oil Shale (47) and Final Report: Revegetation Studies for Disturbed Areas and Processed Shale Disposal Sites (48).

In addition, a preliminary revegetation program has been developed to function in a logical and coordinated fashion. Plant species have been selected that illustrate a high salinity tolerance, compatibility with domestic and wildlife use, and aesthetically desirable features. Plants will not be transplanted from growing media until a hearty root system is developed. After compaction, the disposal pile will be shaped into terraces and slopes so as to minimize erosion and capture precipitation. Surface particle-binding mulches will be applied to the slopes. Trenches 45 cm wide by 75 cm deep (17.7 by 29.5 in.) will be filled with topsoil. The plants will be fertilized to a minimum degree and watered with drip irrigation.

Interim Monitoring Program—

Presently there is no program ensuing for the monitoring of solid wastes because of the fact that no solid wastes are being generated. Since the end of baseline monitoring, two reports have been presented, each dedicated to reporting the progress of continuing research. From January 1, 1977 to June 30, 1977, the main study concerns were: propagation of native plants and container problems, physiological studies of plants grown in saline soils, rehabilitation plantings on disturbed sites, salt movement and chemical weathering in process shale and pilot model, and water harvesting studies. Study concerns from the period July 1, 1977 to December 31, 1977, were : physiological studies, rehabilitation planting on disturbed sites, water harvesting from a saline medium, weathering of processed oil shale, pilot model and associated studies, and research plans.

Commercial Development Phase Monitoring Program—

The solid waste monitoring plan is based on requirements of the Oil Shale Lease and of the Utah State Code of Solid Waste Disposal Regulation, which are summarized in Section 7 of that Regulation. The solid waste disposal plan, including waste sources, and types and quantities expected during the single retort operation and the commercial operation phases, is described in Section 5.3 of the Detailed Development Plan (36). All solid wastes will be deposited in the processed shale disposal area, some uniformly mixed in processed shale, and some layered in processed shale.

The solid waste monitoring program will consist largely of recordkeeping and physical inspection practices. Surface water, groundwater, and ambient air monitoring around the areas of disposal will also supply useful data. Records of disposed wastes will be kept. The record will include types and approximate quantities of solid wastes, the disposal area being employed, and special provisions used for chemical waste disposal. During commercial operation, wastes from Phases II and IV will be inventoried as to types and quantities and will then be mixed with the processed shale for disposal. In addition, a regular program of inspection will be established to ensure that collection, storage, transport, and disposal practices are being carried out in a safe and environmentally acceptable manner.

In the implementation of the water monitoring program, surface water and groundwater quality data will be collected and used to assess the changes, if any, in surface water or groundwater quality attributable to solid waste disposal practices. Samples collected at two streamflow gaging stations will provide data to evaluate surface water quality upgradient and downgradient from the solid waste disposal sites in the processed shale disposal area. In addition, any runoff or leachate collected from the initial solid waste landfilling operations (during construction and before deposition of processed shale) will be sampled semiannually and analyzed. This activity will be supplemented by monitoring the water quality in the Southam Canyon runoff retention pond when processed shale and other solid wastes are being deposited. Groundwater sampling stations will be located in the water-bearing zones, both upgradient and downgradient from the processed shale disposal area, which includes the solid waste disposal area. The groundwater sampling and analysis program will provide information to assess water quality changes that might result from processed shale and solid waste disposal operations.

Air quality monitoring plans associated with processed shale disposal will include monitoring in the solid waste disposal area. The initial solid waste landfill will contain a small amount of decomposable wastes. Although gas evolution is not expected to be detectable over the life of the lease, the site will be checked regularly for gas emissions through the use of a hand-held hydrocarbon sensor. If detected, the gases will be sampled and analyzed to determine whether control measures such as vents or barriers are warranted.

At the conclusion of studies done by Utah State University during the interim and baseline periods, a suitable system of revegetating raw and processed shale will be determined. This system will be utilized to control erosion and nonfavorable aesthetic impacts of shale disposal piles.

Noise

Baseline Data Gathering Program--

Noise data were collected during the first year of baseline data gathering. The data had indicated that sound levels for all seasons were in the range of 24 to 26 dBA. The data indicated that no measurements were warranted during the second year of baseline data gathering. A detailed method of measurement was not described in the First Year Environmental Baseline Report (30) or the Final Environmental Baseline Report (31). Wind, rivers, streams, and wildlife were determined to be the primary sources of noise in the area.

Interim Monitoring Program--

No such program was established because data collected during the baseline program indicated that a continuation of the noise monitoring program was unnecessary during the interim.

Proposed Commercial Development Phase Monitoring Program--

Monitoring of noise levels on Tracts U-a and U-b will be performed as part of the commercial development phase monitoring program. The program is described in the DDP (36). An outline of the program follows.

Two monitoring stations are proposed to monitor the noise levels emanating from the major activity on Tracts U-a and U-b . Both stations will be the same or greater elevation than the process area, and they will be no more than 30.5 m (100 ft) from existing access roads. The ambient noise levels will be recorded with a digital or analog recorder with a sound measuring system that meets ANSI standards for Type I sound level meters. Recordings will be taken for 2 days (two 24-hr periods) at each location during the following stages of program development:

- Before construction
- Construction of the single retort - earth-moving stage
- Operation of the single retort-field capacity
- First train construction - earth-moving stage
- First train construction - full capacity
- Second train construction - earth-moving stage and simultaneous full capacity operation of first train
- Two-train operation - full capacity

None of the above noise measurements would be made during extraordinary events. The instrumentation and measurement techniques will follow the considerations for outdoor environments presented in American National Standards Institute Methods for the Measurement of Sound Pressure Levels (49). In addition, provisions will be made for measuring wind speed at the monitoring location during the monitoring period. The parameters to be used for assessing ambient noise will include:

- Sound pressure level--used to express the loudness of a sound, measured in dBA.
- A-weighted sound pressure level--used for describing the magnitude of sounds in terms of human aural response, measured in dBA.
- Cumulative distribution level - the A-weighted sound pressure level in dBA exceeded for a given percentage of the time, denoted by the subscription.
- Equivalent sound level - the A-weighted steady noise level that, in a stated period of time, contains the equivalent amount of noise energy as the time-varying noise during the same period.
- Day-night sound level - the equivalent A-weighted sound level during a 24-hr time period with a 10-dB weighting applied to the equivalent sound level during the nighttime hours of 10 p.m. to 7 a.m.

Radioactivity

Baseline Data Gathering Program--

During the baseline data gathering program at Tracts U-a and U-b, radioactivity was measured in the ambient air, surface water, groundwater, and the local soil horizons. The main document providing assistance was the First Year Environmental Baseline Report (30).

Ambient radiation was measured continuously at various locations throughout the Tracts during the baseline data gathering programs at Tracts U-a and U-b (31). Three thermoluminescent dosimeters were installed at each of the 12 monitoring stations after June 1975 and were read monthly to determine overall average radiation dosage levels. Before June 1975, a pressurized ion chamber was rotated from site to site at intervals of 6 days. Before the ion chamber was installed at any one of the sites, a portable ionization chamber and scintillation counter were used to survey the area to determine that the continuous measurements would be representative of the area. Gross alpha and gross beta measurements were made monthly. One gamma radiation scan was made of a high-volume filter sample. In addition, one sample of air was analyzed for radon-222 activity. Ambient radioactivity measurements by pressurized ion chamber and hand-held radiation monitor were terminated in January 1976 with the approval of the Area Oil Shale Supervisor. Monitoring by thermoluminescent dosimeters at Stations A1 through A12, analysis of particulates for gross alpha and beta activity, and isotopic gamma analyses continued through the second year of monitoring.

In addition to the monitoring of radiation in the ambient air, radiation levels were determined in local soil horizons, surface water, and groundwater. A number of soil samples were collected from representative locations on the two lease tracts and analyzed for radioactivity. No sources above a normal background level were identified, with Ra^{226} activity below 0.87 pCi/g, Sr^{90} (395 pCi/lg) below 0.52 pCi/g (236 pCi/lb), K^{40} below 20.0 pCi/g (9074 pCi/lb), Pb^{212} below 1.5 pCi/g (681 pCi/lb), and Cs^{137} below 1.6 pCi/g (726 pCi/lb) recorded for all samples. Detailed results of the soil radioactivity tests are appendicized in the First Year Environmental Baseline Report (30). Surface water quality samples were also analyzed for gross alpha (mg/1U), gross beta (mg/1U), gross beta (pCi/1 Cs-137) and gross beta (mg/1 Sr^{90}/Y^{90}).

Interim Monitoring Program--

Radioactivity was measured in the ambient air and in the water and groundwater during the interim monitoring program. Documents that supplied information for this report were the Tract U-a and U-b Progress Reports (33,34) and Suspension Period Work Plan (35).

Ambient radioactivity measurements by pressurized ion chamber and hand-held radiation monitor were terminated in January 1976 with the approval of the Area Oil Shale Supervisor. Monitoring by thermoluminescent dosimeters, analysis of particulates for gross alpha and gross beta activity, and isotopic gamma analyses continued through the second year of baseline data gathering, but has been discontinued until the commencement of commercial construction. It has been determined that no significant radiation exists in the ambient air (33).

Surface water quality samples were also analyzed for gross alpha (mg/l U), gross beta (mg/l U), gross beta (pCi/l Cs^{137}) and gross beta (mg/l Sr^{90}/Y^{90}).

Commercial Development Phase Monitoring Program--

A radiation monitoring program during commercial development at Tracts U-a and U-b has not been proposed. This determination was made after reviewing results of the baseline program and was based on the supposition that oil shale production will not contribute to the ambient radioactivity. If a program is thought necessary in the future, one will be instituted by the Area Oil Shale Office and the WRSP.

Surface Subsidence

Baseline Data Gathering Program—

Surface subsidence was monitored during the baseline data gathering program. The description of the program is presented in the First Year Environmental Baseline Report (30) and the Final Environmental Baseline Report (31). A precise releveling survey was completed for the WRSP to determine whether or not subsidence is occurring within the area.

The survey route was 18.0 km (28.9 mi) long and includes 16 bench marks. The bench marks used were established in 1933 and 1934 by the U.S. Coast and Geodetic Survey. The survey showed little or no subsidence.

Interim Monitoring Program and Proposed Commercial Development Phase Monitoring Program—

Subsidence measurements have been made during the interim monitoring program, and one is proposed for the commercial development phase. The sources of information on this subject are the Progress Reports (33,34) and the Work Plan: Lease Suspension Period (35). Based on rock samples taken from the core of drill holes on Tracts U-a and U-b, the mine is expected to have a safety factor of 2.5, thus making surface subsidence unlikely. However, a monitoring program has been proposed to indicate subsidence if it occurs. Two lines of surveyed stations will be established on the surface overlying the initial mine area. These lines will be perpendicular to each other and oriented in the same direction as the mine entries. They will be set and measured before Phase II mining begins and will be measured periodically for elevation to determine if subsidence is taking place. Initial measurements will be done at least semiannually.

U.S. DEPARTMENT OF ENERGY ROCK SPRINGS RESEARCH SITES

Environmental data gathering programs have been conducted and reported at the DOE Rock Springs research sites since the early 1970's. The Rock Springs sites are located approximately 8 km (5 mi) west of Rock Springs in Section 15, T 18 N, R 106 W of Sweetwater County, Wyoming (Figure C-33). Most of the environmental programs that have been conducted to date have not been outlined and documented in great detail because of the fact that these projects are research-oriented and hence, until recently, have been exempt from stringent environmental control.

All information necessary for completion of this report on environmental programs at the Rock Springs sites was derived from References 50-57.

Air Resources

Air Quality and Meteorology--

Measurements of ambient air quality and meteorology have been made by the DOE on a very limited basis. Air quality monitoring activities, with the exception of particulates, were suspended with the completion of baseline monitoring in October 1977. These baseline measurements, which began in February 1975, consisted of discrete samples taken on 6-day intervals. The data gathered during

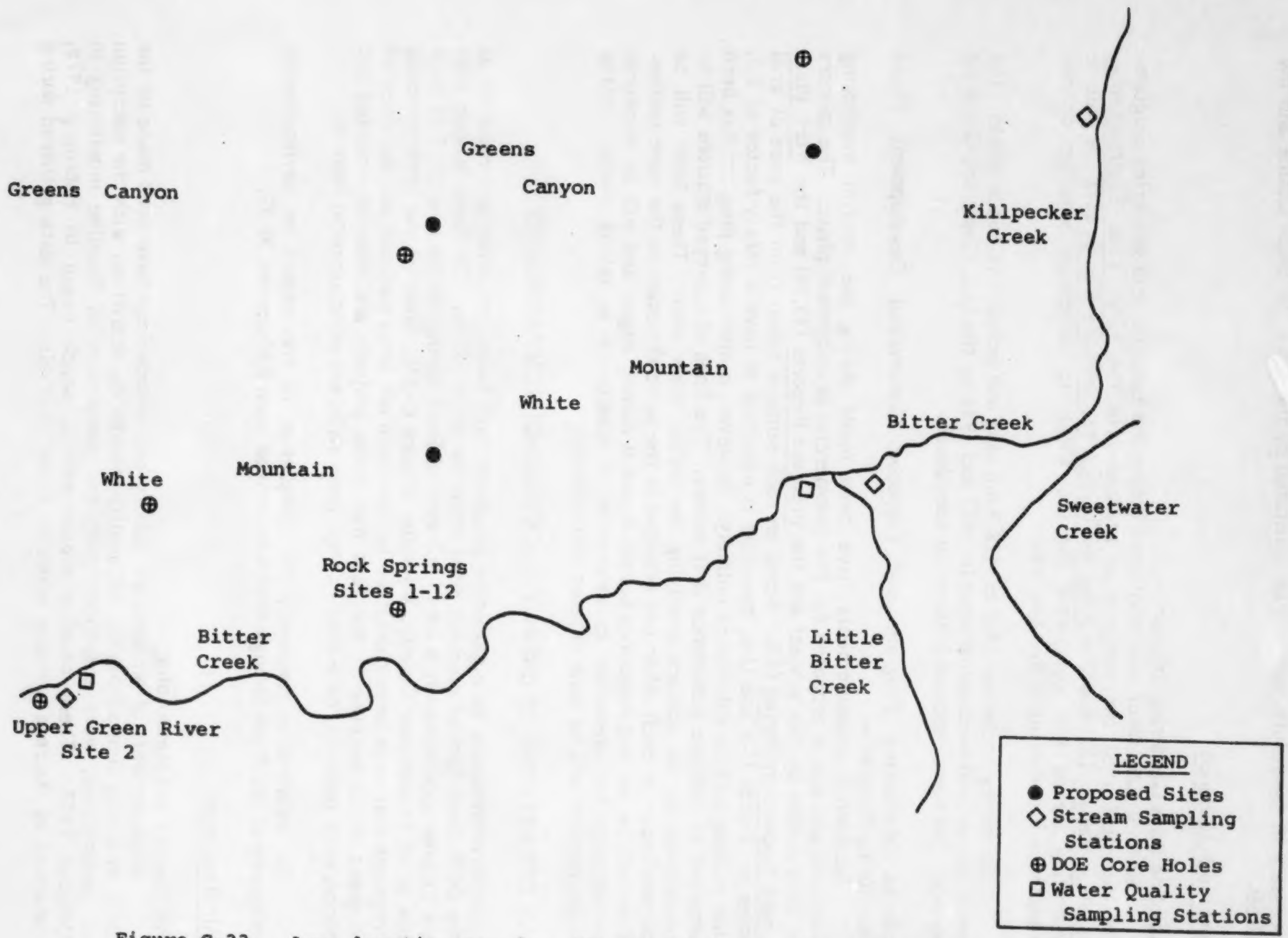
Greens Canyon
Greens
Canyon
Killpecker
Creek
Mountain
White
Bitter Creek
White
Mountain
Sweetwater
Creek
Rock Springs
Sites 1-12
Bitter
Creek
Little
Bitter
Creek
Upper Green River
Site 2
LEGEND
● Proposed Sites
◇ Stream Sampling Stations
⊕ DOE Core Holes
☐ Water Quality Sampling Stations

Figure C-33. Area location map for DOE oil shale in situ research sites.

this period, considering the intermittent sampling scheme and the techniques employed, are not suitable to truly represent mean ambient concentrations, and therefore they have not been subject to analysis.

Preparations are being made at this time to establish a continuous monitoring station near the 30.5 m (100-ft) meteorological tower. This station is operating and will employ Federal reference or equivalent methods for particulates, sulfur dioxide, hydrogen sulfide, carbon monoxide, and ozone.

Meteorology--Wind speed, wind direction, temperature, and delta temperature are measured at the 30.5 m (100-ft) level on the meteorological tower. The instruments were repaired and reactivated in late August 1978 after 5 months of down-time for repair.

Stack gas monitoring--Some monitoring of stack gas effluents has been conducted at Site 9, but details of the program are not available. A list of the stack gas monitoring equipment available to the Laramie Energy Technology Center for future use is presented in Table C-31.

None of the proposed ambient air or stack gas monitoring programs have been published, but a meteorological monitoring program to determine evaporation rates of produced water at Site 12 has been proposed (54).

Water Resources

Baseline Data Gathering Program--

Surface water--Baseline surface water quality and hydrology in the Rock Springs area has been established mainly by the Energy Research and Development Administration (ERDA, now a part of the DOE) and the USGS with data that has been gathered in the past. Surface water quality samples have been collected by the Water Resources Division of the USGS at two locations in the Rock Springs vicinity:

1. Bitter Creek near Green River, Wyoming

2. Green River near Green River, Wyoming

Regional hydrology has been determined by a USGS stream-gaging station on the Green River below the Bitter Creek confluence.

In response to a lack of pertinent water quality and hydrology data, the LETC has established a system of monitoring water resources in the areas more immediate to the Rock Springs research sites.

A small-scale program was first established on a weekly basis from April 28 to July 15, 1976. Flows were measured, and water quality samples were taken at sites below four springs and seeps in the Green Canyon alternate site area and one spring near the primary site above ERDA/LETC Well Number 4.

Groundwater--Before LETC monitoring of static water levels and water quality in Rock Springs groundwater, this information was received through inspection of local, privately owned water wells. Twelve wells were drilled in the

TABLE C-31. LARAMIE ENVIRONMENTAL TECHNOLOGY CENTER PRIORITY AIR POLLUTANT MONITORING EQUIPMENT USED AT DOE ROCK SPRINGS SITES[a]

Units	Mfg.	Model	Effluent	Range	Sensitivity	Remarks
Sulfur oxides:						
3	Meloy Laboratories, Inc.	SA-160-2	SO_2	0-10 ppm	0.005 ppm	---
3	Meloy Laboratories, Inc.	SH-202-2	TS/HC	0-10/0-1000	0.005/0.1 CH_4	---
2	Energetics Science, Inc.	Ecolyzer series 7000	H_2S	Dual 0-100/0-500		---
1	Baseline Industries	TCD1010 Gas chromatograph	SO_2, H_2S			---
1	Baseline Industries	TCD1030 Gas chromatograph	SO_2, H_2S	---	---	---
Nitrogen oxides:						
1	Meloy Laboratories, Inc.	NA-510-2	NO, NO_2, NO_x	0-10 0-100 0-1000 0-2000	0.1 ppm	---
3	Energetics Science, Inc.	Ecolyzer Series 7000	NO_2	Dual 0-50 0-250	---	---
1	Monitor Laboratories, Inc.	8440	NO, NO_2, NO_x	0-0.2 ppm 0-0.5 ppm 0-2.0 ppm 0-5.0 ppm	2 ppb	---
Hydrocarbon & other gases:						
	Meloy Laboratories, Inc.	SH-202-2	As described under sulfur oxides	As described under sulfur oxides	---	---
	Baseline Industries	FID1020	CH_4, THC, CO		---	---
	Mine Safety Appliances Co.	Lira 303	CO_2	0-50%	---	---
	Fisher Scientific Co.	Orsat gas apparatus	O_2, CO_2, N_2, CO, HC		---	---

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[a] Other equipment is available for measuring barometric pressure, humidity, flow, and temperature of gas streams and a special balance for weighing large filters. Dual-pen recorders are used to reduce space requirements. Standard gas mixtures for calibration are housed in the unit while gas cylinders for instrument operation are secured outside the unit. Calibration gas mixtures for Meloy Sulfur analyzers should, where possible, be made up in air rather than nitrogen.

(continued)

TABLE C-31. (continued)[a]

Units	Mfg.	Model	Effluent	Range	Sensitivity	Remarks
Auxiliary equipment:						
3	Meloy Laboratories, Inc.	Pneumotron	---	---	---	Self-contained pneumatic dilution device - Dilution factor 4 to 40
1	Monitor Labs, Inc.	Attenutron Model 3710	---	---	---	Dilution device employing a semi-permeable diffusion barrier
2	Meloy Laboratories, Inc.	Sampletron Model 5530-2	---	---	---	Sample conditioner permits measurement of total sulfur, hydrogen sulfide and sulfur oxides as SOX
3	Meloy Laboratories, Inc.	CS10-2	---	---	---	SO_2 calibration source, 0.1 to 0.8 ppm from permeation tube, ± 2% accuracy
1	Meteorological Station	---	---	---	---	---
Stack monitoring equipment - special:						
1	Research Appliance Co.	Stack gas train	---	---	---	36"-Probe, impinger train, modular electrical unit with manometers, pitot (S-type) tube and pump. Equipped with an Alundum thimble filter and Andersen in-stack fractionating sampler assembly.
3	Research Appliance Co.	High-volume air sampler, deluxe model	---	---	---	Continuous-duty, 24-hr cycles (or longer), 7-day skiptimer also equipped with an Andersen particle sizing sampling head and variable 90-volt transformer.

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[a] Other equipment is available for measuring barometric pressure, humidity, flow, and temperature of gas streams and a special balance for weighing large filters. Dual-pen recorders are used to reudce space requirements. Standard gas mixtures for calibration are housed in the unit while gas cylinders for instrument operation are secured outside the unit. Calibration gas mixtures for Meloy Sulfur analyzers should, where possible,.be made up in air rather than nitrogen.

area from 1970 to 1975. These wells were sampled for water quality and have been sampled periodically since 1976.

Existing Monitoring Program--

Surface water--since 1976 there has been very little surface water monitoring in the Rock Springs area. The data that have been gathered are not well documented, and a summary of the sampling procedures is presently unavailable for publication.

Groundwater--There are numerous wells in the Rock Springs area. Maps showing regional location and well patterns at individual research sites are presented in Figures C-33 and C-34. The following parameters are measured monthly at Sites 6, 9, and 10 and quarterly at Green River Site 2 and the Upper Green River Basin: Na, K, Ca, Mg, Cd, Cl, F, NO_3, SO_4, CO_3, HCO_3, PO_4-Ortho, NH_3-N, TDS, hardness, total alkalinity, pH, conductivity, COD, TKN, DOC, TIC, TC.

This monitoring program is expected to continue indefinitely, with the possibility that monitoring frequency at Green River Site 2 and Upper Green River Basin will be extended to annual sampling.

Proposed Monitoring Programs—

At Rock Springs Site 12, the water resources monitoring program is more sophisticated, since it has been developed more recently. Observation wells have been drilled in a semicircle around the central areas (Wells E5, E6, 5 and 7), as shown in Figure C-34. These wells will be monitored in the preoperational, operational, and post-operational phases of Site 12 development. The schedule of proposed monitoring is presented in Table C-32. The parameters to be analyzed under schedules A, B, and C are listed as follows:

Analysis Schedule A Parameters:

Alkalinity
Ammonium ion/ammonia
Bicarbonate/carbonate
Boron
Calcium
Chemical oxygen demand (COD)
Chloride
Conductivity
Magnesium
Oil and grease
  (separation tank and
    evaporation pond only)
pH
Potassium
Residue on evaporation (ROE)
Sodium
Sulfate
Thiosulfate
Total Kjeldahl nitrogen (TKN)

Analysis Schedule B Parameters:

Arsenic
Cyanide
Mercury
Selenium
Tetrathionate
Thiocyanate

Analysis Schedule C Parameters:

Aluminum
Barium
Cadmium
Chromium
Copper
Fluoride
Iron
Lead
Manganese
Nickel

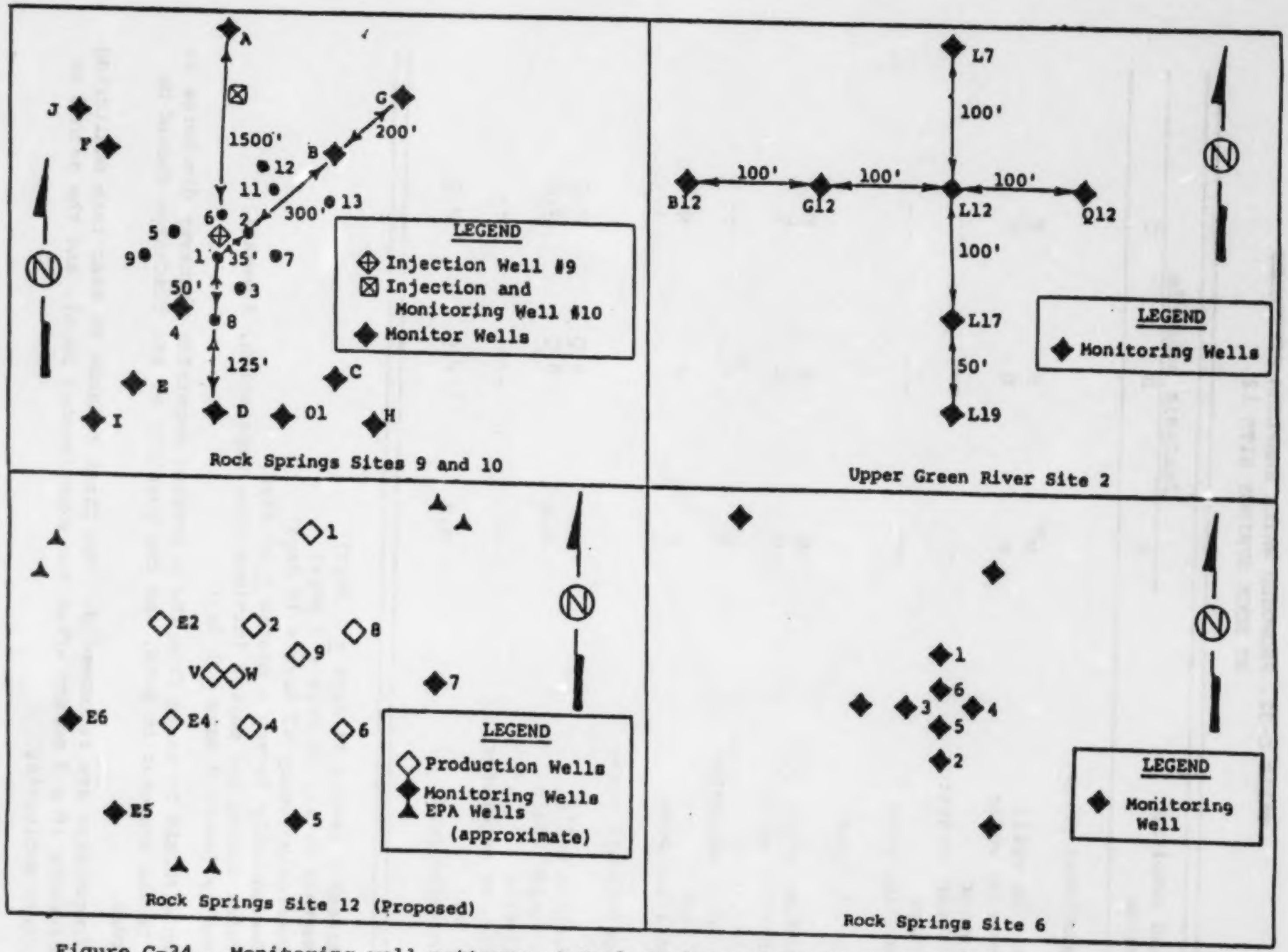

A
J
F
1500'
G
200'
B
12
11
13
6
2
300'
5
9
1
35'
7
50'
3
4
8
125'
E
C
I
D
01
H
LEGEND
Injection Well #9
Injection and Monitoring Well #10
Monitor Wells
Rock Springs Sites 9 and 10
L7
100'
B12
100'
G12
100'
L12
100'
Q12
100'
L17
50'
L19
LEGEND
Monitoring Wells
Upper Green River Site 2
1
E2
2
8
9
V
W
7
E6
E4
4
6
E5
5
LEGEND
Production Wells
Monitoring Wells
EPA Wells (approximate)
Rock Springs Site 12 (Proposed)
1
6
3
4
5
2
LEGEND
Monitoring Well
Rock Springs Site 6

Figure C-34. Monitoring well patterns at Rock Springs research sites and Upper Green River.

TABLE C-32. PROPOSED WATER SAMPLING SCHEDULES AT ROCK SPRINGS SITE 12

Phase and sampling location	Analysis schedule		
	A	B	C
Pre-operational phase:			
Production wells	W[a]	B	T
Observation wells	W	B	T
(Collector			
(Oil-water separator	---	---	---
(Oil tank			
Evaporation pond	---	---	---
Operational phase:			
Production wells	W	B	T
Observation wells	W	B	T
(Collector			
(Oil-water separator	W[b]	W[b]	---
(Oil tank			
Evaporation pond	B	M	M
Post-operational phase:[c]			
Production wells	W,M	B,Q	T,S
Observation wells	W,M	B,Q	T,S
(Collector			
(Oil-water separator	---	---	---
(Oil tank			
Evaporation pond	B,M	M,Q	M,Q

[a] B - Biweekly (every 14 days ± 2 days)
M - Monthly (every 30 days ± 3 days)
Q - Quarterly (every 90 days ± 10 days)
S - Semiannually (every 6 months ± 20 days)
T - Twice during the period (minimum time separation, 3 weeks)
W - Weekly (every 7 days ± 1 day)

[b] A sample should be taken from the oil-water separator whenever discharge is made to the evaporation pond, and the quantity of the discharge should be recorded.

[c] Two frequencies are recommended: The first relates to near-term monitoring requirements (for 3 months after the experimental burn), and the second to long-term monitoring.

Total inorganic carbon (TIC)	Nitrate
Total organic carbon (TOC)	Sulfide
	Zinc

The wells will be pumped before sampling to achieve a water volume representative of the surrounding aquifer. Some measurements will be made in the field, and others will be made in a water quality laboratory. Appropriate preservation and transporting practices will be employed.

Biological Resources

Vegetation--Plant collections were made in spring 1976 by walking the Rock Springs research area. Collections were identified and confirmed using the Rocky Mountain Herbarium located at the University of Wyoming. Concurrently, vegetation maps were compiled by using photographs.

Two sites were surveyed (the alternate and primary site) by the line intercept method. The quandrants and line transects were taken in what was considered to be the center of each homogenous plant community. 30.5 cm (1 ft) quadrants were positioned every 3 m (10 ft) along a 30.5 m (100 ft) tape stretched above the shrub layer.

Shrub cover was determined by the line intercept technique. The 30.5 m (100-ft) tape was positioned in a random manner. The 30.5 cm (1 ft) square quandrant was divided by two crossbars perpendicular to each other and centered within the 30.5 cm (1 ft) square. One crossbar had an arrow painted on it. The 30.5 m (100 ft) tape was placed at the edge of the quadrant and stretched in the direction of the arrow. In areas where narrow homogenous plant communities existed, the tape was centered within the community and stretched parallel to the edges.

Birds--

A literature search was first conducted, and then observations were carried out by walking through the area in the morning and evening. Birds were identified according to species. No estimation of density was attempted.

Mammals--

Large mammals were surveyed using visual observation in the early morning and evening. Pellet transects were taken to verify area use.

Small mammal species were identified through literature search.

Aquatic Biota--

Four reaches of Bitter Creek and Killpecker Creek were selected for aquatic biota sampling considering: Relationship to future DOE sites, representation to future DOE sites, representation of other reaches, and accessibility. Field measurements were conducted on May 15, 1975, at each study site.

Fish collections were made using 25-ft nylon seines having a depth of 1.2 m (4 ft) and a 0.4763 cm (0.1875 in.) mesh size. For each fish collected, total length was measured to the nearest 1.0 mm (0.04 in.), and weight was recorded to the nearest 1.0 g (0.28 oz). To avoid misidentification of the species collected, representative individuals were preserved in 95 percent alcohol and transported to Laramie for verification. Fish population estimates were made.

To survey the benthic invertebrate populations, five bottom fauna samples were taken at each study site, with each sample encompassing an area of 0.023 m^2 (0.25 ft^2). Random number tables were employed to select sampling locations. All collections were made using an Eckman dredge (a spring-operated, jaw-type sampler because of the soft mud and sand substrate present. The benthic invertebrates collected were then identified using available keys, enumerated, and placed on a number/.09 m^2 (1.0 ft^2) basis. Shannon Diversity Index values were calculated for each site to facilitate comparisons of benthic community structure.

Physical and Chemical--
Discharge was measured at the Bitter Creek study sites using a Price current meter and top-setting rod, following standard USGS procedures. Flow could not be measured at the Killpecker Creek sites because of extremely shallow water.

Field measurements were taken for pH, specific conductance, dissolved oxygen, and temperature using the following equipment:

1. Sargent-Welch Model PBL pH meter
2. Yellow Springs water temperature and specific conductance meter
3. Yellow Springs dissolved oxygen meter

Turbidity samples were collected and analyzed in Laramie using a Hach turbidimeter.

Solid Wastes Disposal, Revegetation

Where applicable, revegetation of the mine site will be implemented. The plans covering this aspect of the project include the following:

a. LETC will accomplish revegetation of all affected lands in a manner consistent with the approved reclamation plan and the proposed future use of the land.

b. Land that did not support vegetation before becoming affected land because of natural soil conditions will not be revegetated unless subsoil from such affected land will support vegetation.

c. After backfilling, grading, contouring, and replacing topsoil and/or an approved substitute in such a manner as to accommodate most efficiently the retention of moisture and control erosion on all affected lands to be revegetated, LETC will fulfill any fertilizer requirements as determined on the basis of previous analyses.

Seeding that is accomplished by mechanical drilling will be on the contour unless specific situations dictate that other methods of seeding be used.

d. The species of plants (grasses, legumes, forbs, shrubs, and trees) seeding rates, seeding techniques, mulching requirements, and seeding times to be used in a given area for reclamation purposes shall be in accordance with rules, regulations, specifications, and standards adopted by the State Conservation Commission and approved by the Land Quality Division. Whenever practicable, the Wyoming Game and Fish Department and the Wyoming Department of Agriculture may be consulted regarding revegetation procedures. Seed types will depend on the climatic and soil conditions prevailing in the permit area and the proposed use of the land after reclamation. Species to be planted as permanent cover shall be self-renewing. Seeding rates will depend on seed types, climatic and soil conditions, and the techniques to be used in seeding.

e. More suitable species of vegetation may be substituted if revegetation test plot results show such species to be of superior value for reclamation purposes.

f. LETC will protect young vegetative growth from being destroyed by livestock by fencing or other approved techniques for a period of at least 2 years, or until the vegetation is capable of renewing itself without supplemental irrigation or fertilization.

g. In those areas where there were very few or no noxious weeds before being affected by mining, LETC will control and prevent the introduction of noxious weeds into the revegetated areas for a period of at least 5 years after the initial seeding.

Noise

No programs for the monitoring of noise have yet been designed.

Radioactivity

No programs for the monitoring of radioactivity have yet been designed.

Surface Subsidence

No programs for the monitoring of surface subsidence have yet been designed.

PARAHO

Air Resources

Stack effluent data at Anvil Points have been accumulated by the Gulf Energy and Minerals Co. (May 5-16,1975), Rocky Mountain Technology (November 25-26, 1975), and TRW, Inc. (March 6-15, 1976). The data were obtained during retorting operations from all stationary sources, including boiler stacks, thermal oxidizers, and the retort external heaters. In addition, the heater stacks were monitored frequently during the direct and combination runs. Monitoring was performed on the thermal oxidizer stack during 1976. The air quality parameters that were measured are listed in Table C-33.

TABLE C-33. AIR QUALITY PARAMETERS MEASURED DURING THERMAL OXIDIZER STACK MONITORING

Source	Parameter							
	O_2	CO	CO_2	HC	H_2S	SO_2	NO_x	NH_3
Recyle gas	X		X		X	X	X	X
Boiler stacks	X	X	X	X		X	X	
Thermal oxidizer stacks	X	X	X	X		X	X	X
Pilot plant heater stacks	X	X	X	X				
Semi-works heater stacks	X	X	X	X		X		

During this period of time, Development Engineering, Inc. monitored air (process gaseous emissions, ambient air quality, and meteorology) to satisfy DOE contracts.

Process Gaseous Emissions--

During various periods of time in 1977 and 1978, the thermal oxidizer at Paraho was sampled weekly, and the rotary seal leakage was monitored weekly (October 1977 - June 1978). During the same period, recycle gas and headspace from the raw shale bins were also analyzed periodically. Gaseous and particulate sampling of the thermal oxidizer discharge was done through an available port in the stack. Recycle gases were sampled between the electrostatic precipitator and the recycle gas blower. Gas samples were taken using an integrated gas sampling train. The gas was pulled through a stainless steel probe and an ice bath condenser. A flow meter measured flow into a Tedlar bag. A high-volume source assessment sampling system was used to monitor particulates. About 1,200 standard liters (42 cu. ft) of sample gas were processed in each test for high accuracy. A diagram illustrating the locations of these sampling sites is presented in Figure C-35. The air quality parameters addressed, and the methods of analysis for process emission monitoring are shown in Table C-34.

Ambient Air--

The ambient air around the mine (Adits No. 1 and 2), haul road, crusher, retort and shale disposal areas was monitored for 2-week periods to determine particulate and priority air pollutant concentrations. All four areas were monitored in December 1972 and January 1978.

O_2, CO_2, CO, and CH_4 were measured using GC. Metals were measured using AAS, and SO_2 and NOx were measured using colorimetry. Particulates were sampled with a high-volume sampler, tape sampler, and Cascade Impactor.

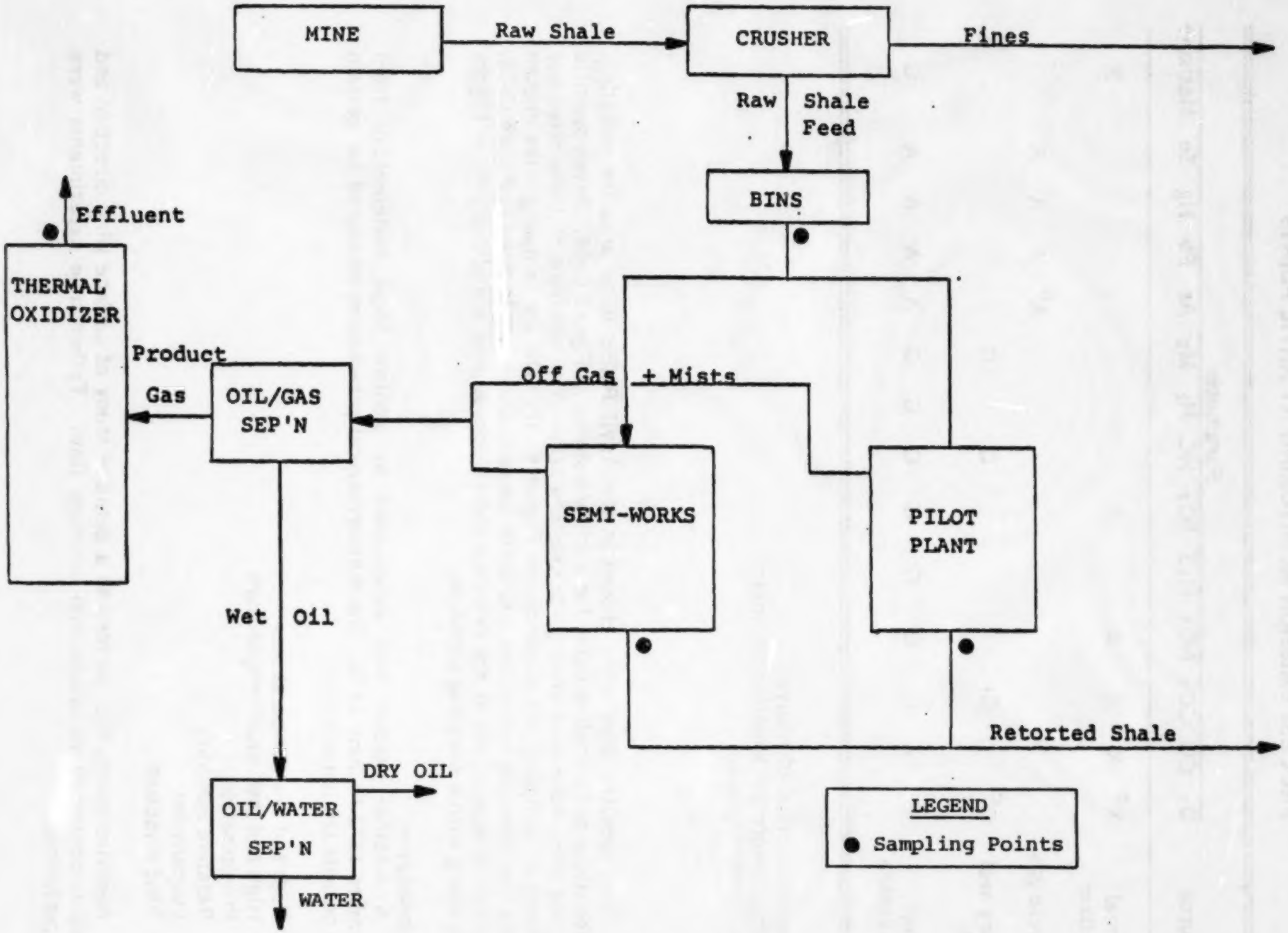

MINE
Raw Shale
CRUSHER
Fines
Raw Shale Feed
BINS
Effluent
THERMAL OXIDIZER
Product Gas
OIL/GAS SEP'N
Off Gas + Mists
SEMI-WORKS
PILOT PLANT
Wet Oil
Retorted Shale
DRY OIL
OIL/WATER SEP'N
WATER
LEGEND
● Sampling Points

Figure C-35. Sampling points of gaseous process emissions at Anvil Points operations, Colorado.

TABLE C-34. AIR QUALITY PARAMETERS AND METHODS OF ANALYSIS FOR PROCESS EMISSION MONITORING AT ANVIL POINTS

Source	Parameter													
	O_2	CO	CO_2	NOx	H_2S	SO_2	HC	H_2	M_2	Ar	Pb	Hg	Se	Methane
Thermal oxidizer	X[a]	X	X	X		X								X
Recycle gas										A[b]	A	A	A	
Rotary seal leak	G[c]		G				G		G					
Storage headspace	G	G	G	G	G	G	G	G	G	A	A	A	A	G

[a] Unknown method of analysis
[b] Atomic absorption spectrophotometry
[c] Gas chromatograph

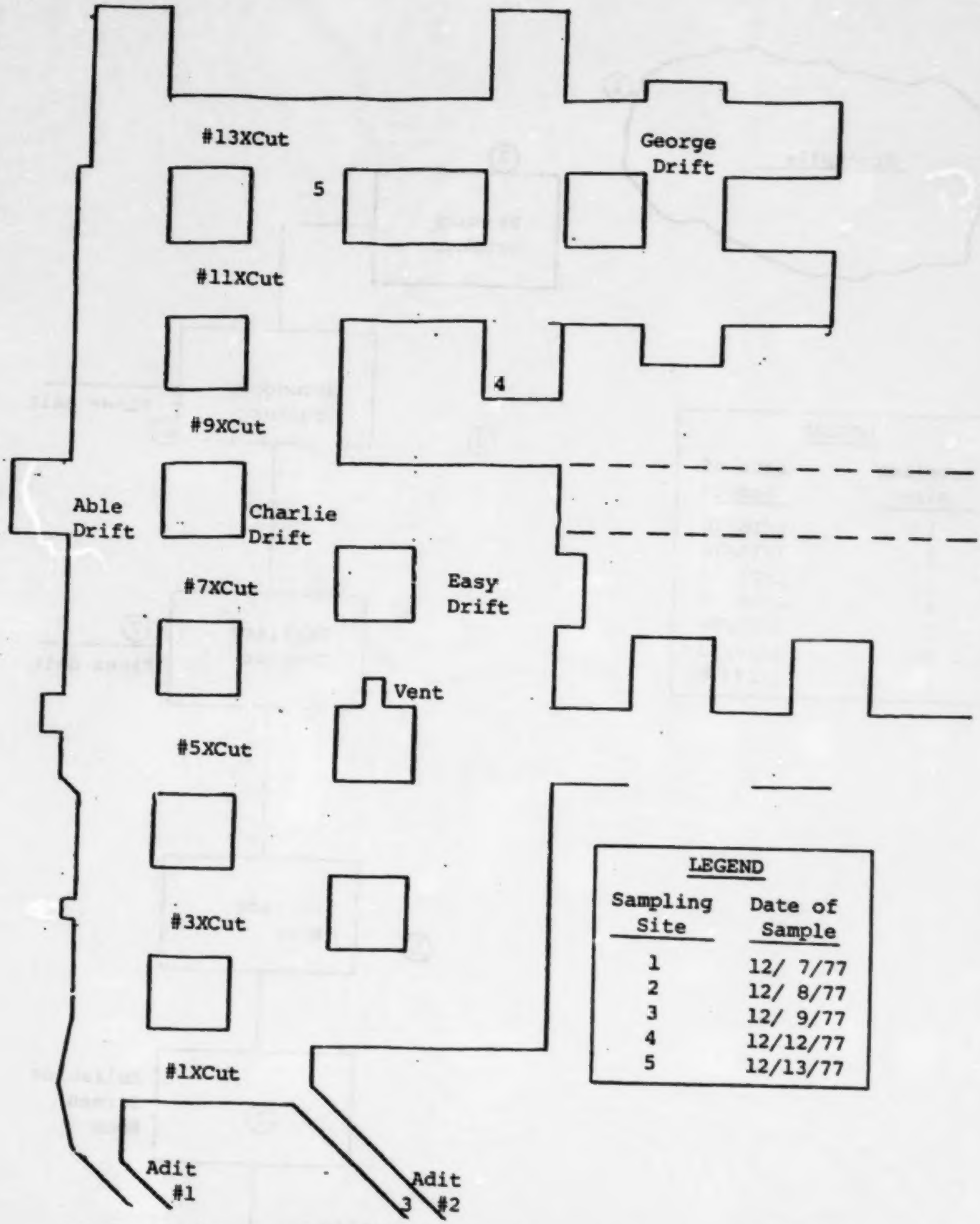
Five specific sites were chosen in the Anvil Points mine area for sampling. The locations and sampling dates for each are shown in Figure C-36. Seven specific sampling sites were used around the crushing area. The locations of these sites and the dates of sampling are presented in Figure C-37. The six sampling sites chosen around the retorting operations and shale disposal areas are located in Figure C-38. The three sites selected at the retorted shale disposal area are also shown in Figure C-38, along with a sampling schedule.

Meteorology—

A weather station was established to monitor local meteorology from December 1972 to June 1978. The meteorological parameters measured for certain time periods are listed below.

High and low temperatures
High and low mean temperature
Precipitation
Relative humidity
Evaporation
Wind direction

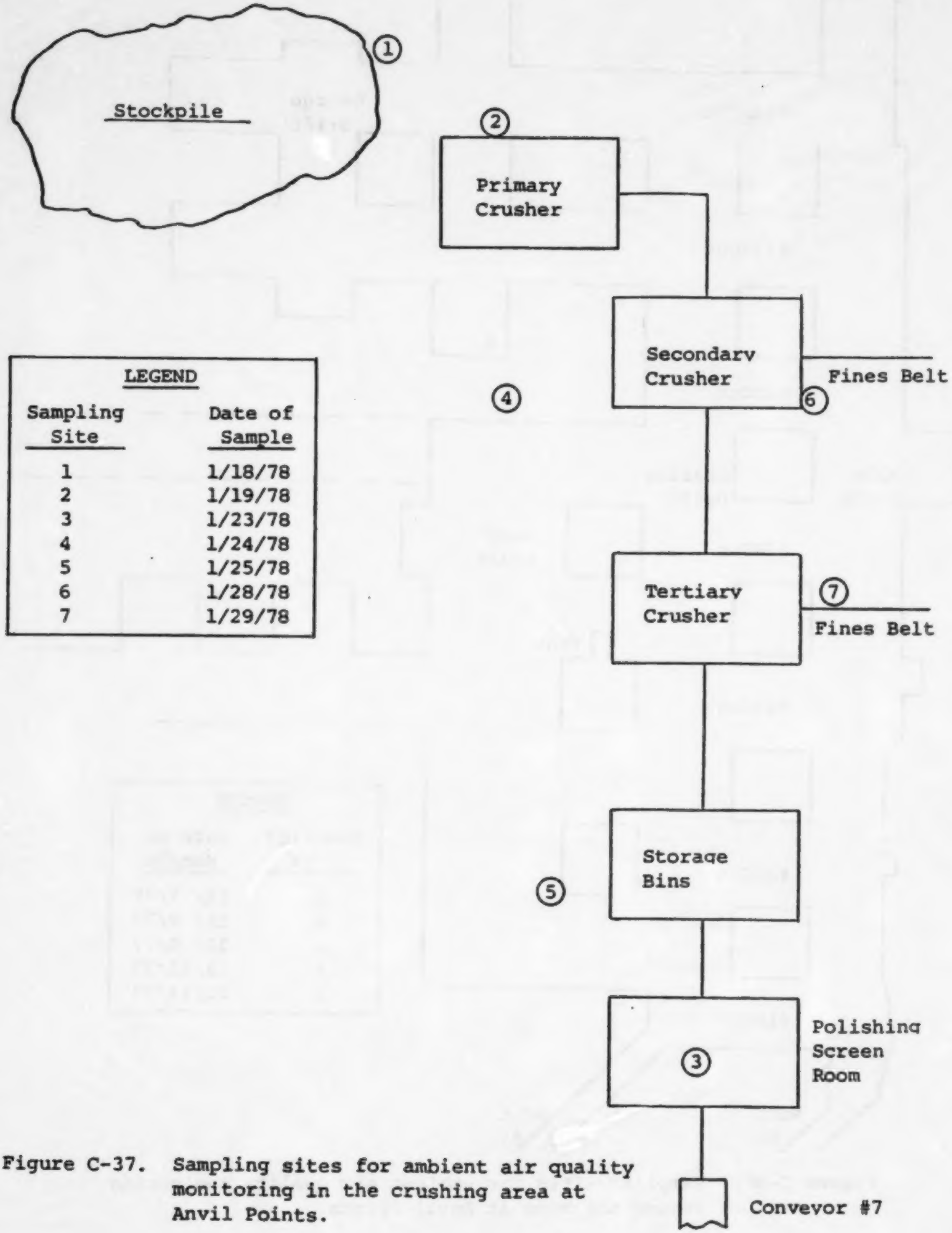
Aerovironment, Inc. performed a detailed study of surface wind direction and speedy temperature variations and drainage flow. Tethersonde experiments were also performed.


#13XCut
5
George
Drift
#11XCut
4
#9XCut
Able
Drift
Charlie
Drift
#7XCut
Easy
Drift
Vent
#5XCut
#3XCut
#1XCut
Adit
#1
Adit
3
#2

LEGEND

Sampling Site	Date of Sample
1	12/ 7/77
2	12/ 8/77
3	12/ 9/77
4	12/12/77
5	12/13/77

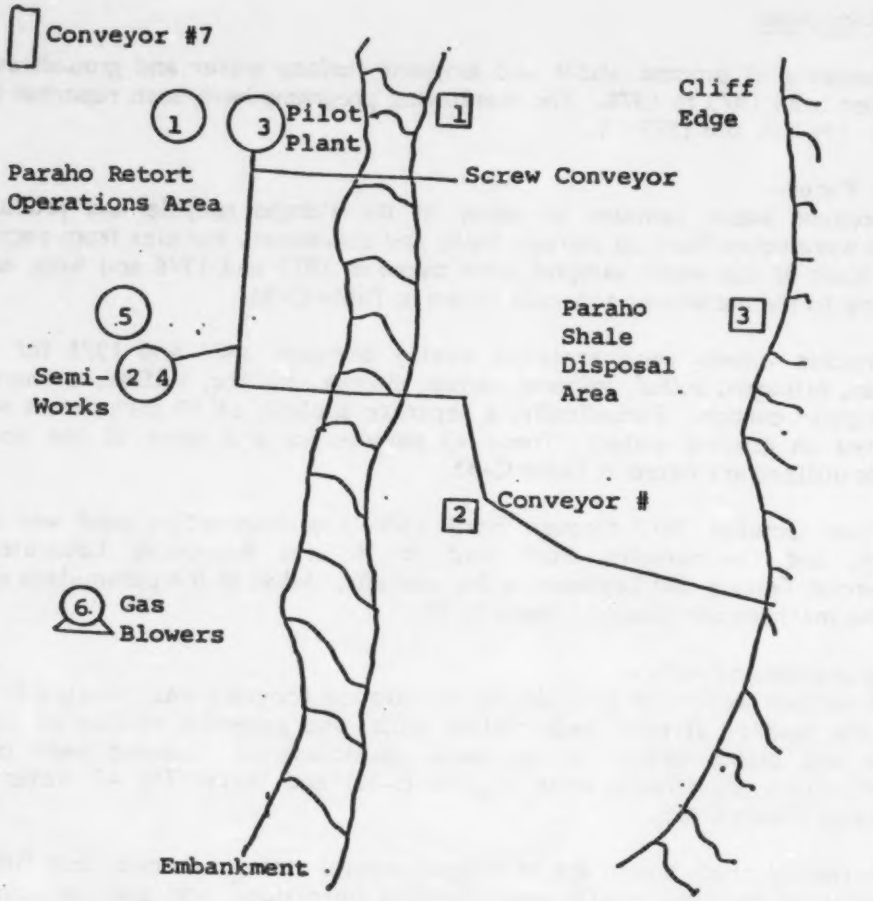
Figure C-36. Sampling sites for ambient air quality monitoring around the mine at Anvil Points.


①
Stockpile
②
Primary Crusher
Secondary Crusher
④
⑥
Fines Belt
Tertiary Crusher
⑦
Fines Belt
Storage Bins
⑤
Polishing Screen Room
③
Conveyor #7

LEGEND

Sampling Site	Date of Sample
1	1/18/78
2	1/19/78
3	1/23/78
4	1/24/78
5	1/25/78
6	1/28/78
7	1/29/78

Figure C-37. Sampling sites for ambient air quality monitoring in the crushing area at Anvil Points.


Conveyor #7
1
3
Pilot Plant
1
Cliff Edge
Paraho Retort Operations Area
Screw Conveyor
5
Paraho Shale Disposal Area
3
Semi-Works
2 4
2
Conveyor #
6
Gas Blowers
Embankment

LEGEND

Retort Sampling

No.	Location	Date
1	Bottom Rotary Seal	12/22/77
2	Middle Distributor	12/23/77
3	Top Rotary Seal	12/24/77
4	Top Rotary Seal	12/26/77
5	Bottom Rotary Seal	12/27/77
6	Gas Blower	12/30/77

Retorted Shale Sampling

No.	Location	Date
1	N. of Screw Conveyor	1/ 8/78
2	Retorted Shale Belt	1/12/78
3	Between Belt and Conveyor	1/22/78

Figure C-38. Sampling sites for ambient air quality measurements around the retorting operations and shale disposal areas at Anvil Points.

Water Resources

Sampling of process water and ambient surface water and groundwater was conducted from 1973 to 1978. The monitoring programs have been reported for two periods: 1973-76 and 1977-78.

Process Water--

Because water remains as vapor in the Paraho recycle and product gas, samples were taken from oil storage tanks and condensate samples from recycle gas lines. Most of the water samples were taken in 1975 and 1976 and were analyzed according to the parameter schedule shown in Table C-35.

Process waters were analyzed weekly between 1977 and 1978 for carbon, hydrogen, nitrogen, sulfur, mineral carbon dioxide, sulfate, sulfide, ammonia, and total organic carbon. Periodically, a separate analysis of 43 parameters was also conducted on process water. These 43 parameters and some of the analytical methods utilized are listed in Table C-35.

From October 1977 through April 1978, the evaporation pond was sampled monthly, and the samples were sent to Natural Resources Laboratory and Commercial Testing and Engineering for analysis. A list of the parameters analyzed and some methods are shown in Table C-35.

Surface and Groundwater--

A surface water and groundwater monitoring program was initiated in 1974 to assess the salinity effects, hydrocarbon spills, and potential release of toxins to animals and plants caused by oil shale development. Samples were collected quarterly from six stream sites (Figure C-39) and tested for 43 water quality parameters (Table C-35).

A special study was made to sample several streams from Balzac Gulch that flow adjacent to mine traffic and retorting operations, and also to sample one stream that is not at all affected. The study was a one-time sampling in October 1975.

Six surface streams continued to be monitored between 1977 and 1978. The water was analyzed for the parameters noted in Table C-35. Identical samples were sent to Natural Resources Lab and Commercial Testing and Engineering for analysis.

Other Environmental Studies

Several additional studies have been conducted at the Paraho project to determine the impacts of oil shale development on air quality, water quality, and public health. Although these studies are not available for public review, they are mentioned briefly here for future reference.

The Los Alamos Scientific Laboratory was contracted by the DOE to monitor fugitive dust and all priority gaseous pollutants in the mine, crushing, retorting and shale disposal areas of the Paraho project. Some materials related to the process were analyzed for toxicology purposes. A small amount of work was also done on noise monitoring.

TABLE C-35. WATER QUALITY PARAMETERS AND METHODS OF ANALYSIS EMPLOYED DURING PROCESS WATER, SURFACE WATER, AND GROUNDWATER MONITORING AT ANVIL POINTS

Parameters, ppm	Method of Analysis[a]
Aluminum	A
Arsenic	A
Barium	A
Boron	A
Cadmium	A
Calcium	A
Chromium	A
Copper	A
Iron	A
Lead	A
Magnesium	A
Mercury	A
Molybdenum	A
Potassium	A
Selenium	A
Silver	A
Sodium	A
Silicon	A
Zinc	A
Alkalinity as $CaCO_3$	T
Carbonates as CO_3	C
Carbon, total	P
Carbon, organic	P
Chemical oxygen demand	T
Chloride	---
Cyanide	I
Fluoride	I
Hydrogen, total	P
Nitrogen, total	C
Nitrogen, ammonia	C
Nitrogen, nitrate	C
pH	---
Phenol	C
Phosphate, total	C
Suspended	G
Dissolved solids, total	G
Sulfate	---
Sulfide	G
Sulfur, total	T
Salinity	---
Oil and grease	---
Silica	---
Kjeldahl nitrogen	---

[a] P = Perkin Elmer elemental analyzer
L = LECO sulfur analyzer
T = Titrametric techniques
C = Colorimetric techniques
A = Atomic absorption
I = Ion sensing electrodes
G = Gravimetric techniques

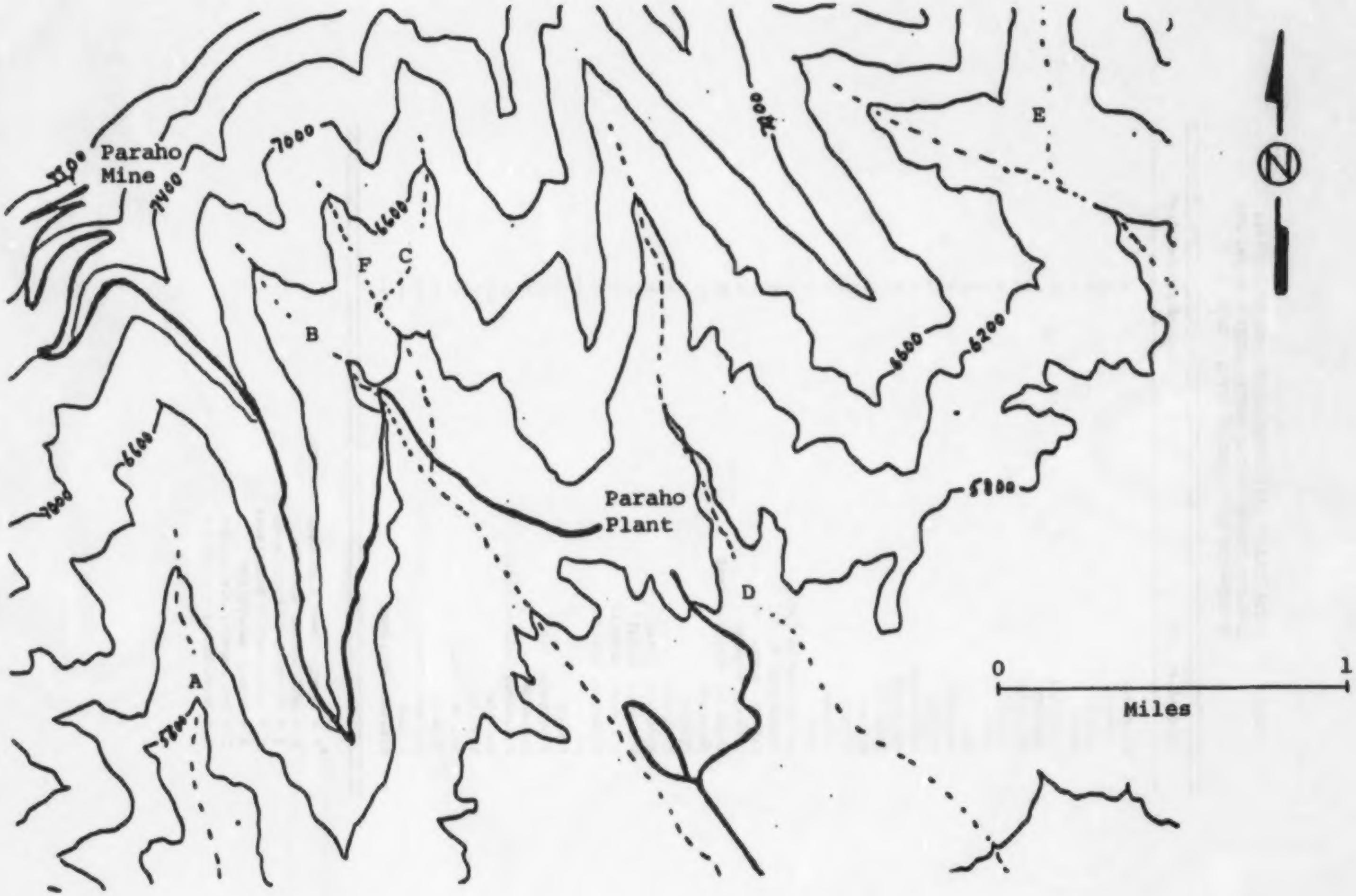

7700
Paraho
Mine
7400
7000
6600
F
C
B
7400
E
6600
6200
5800
Paraho
Plant
D
7000
6600
A
5800
N
0
1
Miles

Figure C-39. Locations of stream sampling sites at Anvil Points.

The EPA commissioned the Oak Ridge National Laboratory (ORNL) to conduct health effects and toxicology assessments on process solid and liquid wastes.

Gulf South Research Institute has conducted process, groundwater, and surface water quality monitoring under the direction of EPA.

Battelle Northwest, under the direction of DOE, has performed analyses of process water and gaseous emissions. In addition, analyses of raw and retorted shale have been conducted.

Under a joint program with the University of Colorado, Colorado School of Mines, and Colorado State University, the DOE has conducted research on retorted shale as it relates to land disturbance, revegetation, and leaching of undesirable compounds.

Solid Wastes Disposal, Revegetation

A study was conducted by Colorado State University for the EPA to determine the effects of leaching spent shale disposal piles and to test various methods of spent shale revegetation.

Two lysimeters (waterproof containment areas designed to help determine percolation and leachate characteristics), each 13.4 m (44 ft) wide by 40 m (131.2 ft) long and 2.4 m (7.9 ft) deep, were constructed to simulate the disposal system described above. The lysimeters were constructed of reinforced concrete with water stops between the cold seams. Each lysimeter has a 25-percent slope representing the fill face and a 2-percent slope representing the fill area. In the lysimeters, a 90-cm (35.4 in.) deep layer of compacted retorted shale (1.5 to 1.6 g/cm^3 or .027 to .028 oz/in.^{3}) was covered with a 150-cm (59.0 in.) uncompacted zone (1.2 to 1.4 g/cm^3 or .042 to .049 oz/in.^{3}) (Figure C-40). The study was designed with two lysimeters to provide replication for mathematical hydrological modeling work during the leaching phase, and then to serve as separate units in which to simulate both a high-elevation (moist) and a low-elevation (dry) disposal site.

The study site is 0.3 km (0.19 mi) south-southwest of the housing area at the U.S. Department of Energy, Anvil Points Oil Shale Research Facility. The study site, which is on public land managed by the Bureau of Land Management, is characteristic of a low-elevation disposal site with an elevation of 1,737 m (1.08 mi) and a mean annual precipitation of approximately 28 cm (11.0 in.). Both lysimeters were built at this site because of its proximity to water, electricity, retorted shale, and concrete construction supplies. Greater precipitation and less evaporation at a high-elevation disposal site was simulated in one of the lysimeters by applying additional irrigation water.

The following six treatments were tested in each lysimeter on both a 2-percent and a 25-percent slope:

1. Retorted shale to the surface (shale treatment), leached
2. 20-cm (7.9 in.) soil cover over retorted shale, leached

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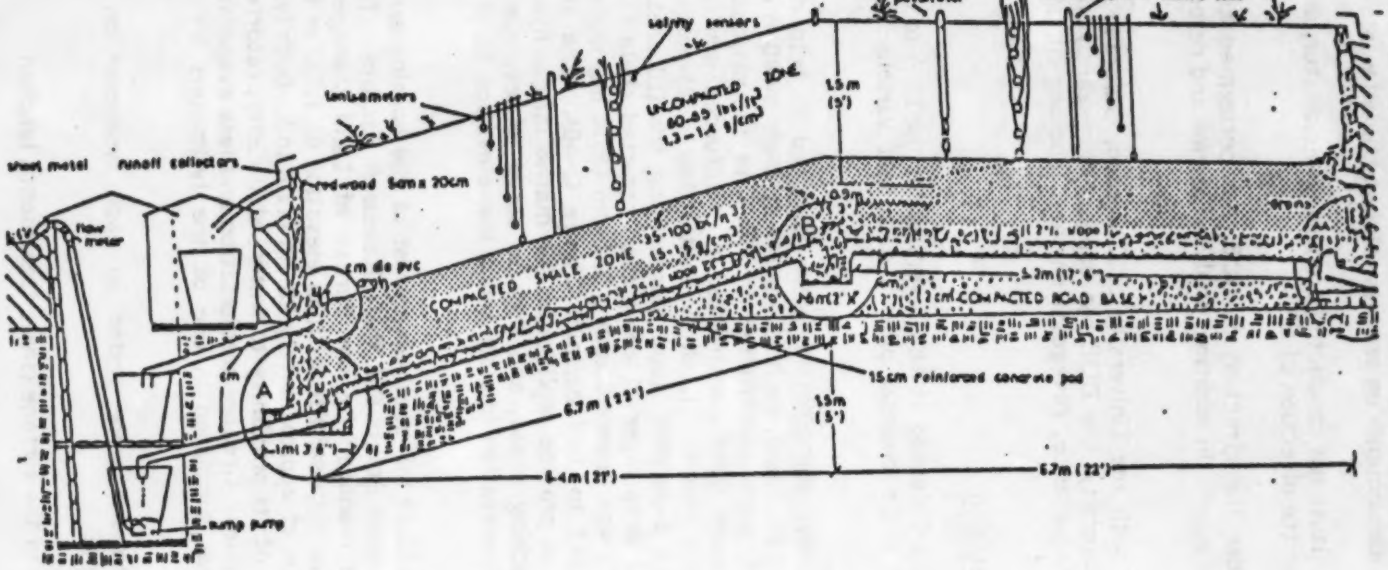
sheet metal
runoff collectors
redwood 5cm x 20cm
flow meter
tensiometers
salinity sensors
UNCOMPACTED ZONE
80-85 lbs/ft³
1.3-1.4 g/cm³
1.5m
(5')
piezometer
neutron probe access tube
cm dia pvc
COMPACTED SHALE ZONE 95-100 lbs/ft³
1.5-1.6 g/cm³
A
B
0.3m
(1')
drains
5.3m (17' 6")
COMPACTED ROAD BASE
15cm reinforced concrete pad
6.7m (22')
1.5m
(5')
6.4m (21')
6.7m (22')
1m (3' 6")
sump pump

Figure C-40. Cross section showing the design of the lysimeters at the Paraho Development.

3. 40-cm (15.7 in.) soil cover over retorted shale, unleached

4. 60-cm (23.6 in.) soil cover over retorted shale, unleached

5. 80-cm (31.5 in.) soil cover over retorted shale, unleached

6. soil control, unleached

Thus within each lysimeter there are 12 treatment areas 6.7 by 6.7 m (7.3 by 7.3 yd), six with a 2-percent north-facing slope, and six with a 25-percent south-facing slope. Each of the 12 treatment areas has an upper drain at the interface of the compacted and uncompacted zones and a lower drain beneath the compacted zone.

Each of the 12 treatment areas are separated into two side by side vegetation and surface runoff replications (3.4 by 6.7 m or 3.7 by 7.3 yd) divided at the surface with a redwood board. Each 3.4 by 6.7 m (3.7 by 7.3 yd) replication has a set of instruments to monitor water and salt movement and a surface runoff collector. The location and plot plan for each of the treatments and replications are shown in Figure C-41.

COLONY DEVELOPMENT OPERATION

Air Resources

Baseline Data Gathering Program--

Since the Colony Development Operation (CDO) is not on Federally-leased land, it was not necessary to satisfy a 2-year baseline study lease stipulation. However, many studies have been conducted for CDO since the 1960's to determine if the plant could be located at several different sites on the Dow property without creating air pollution in excess of State and Federal standards. The baseline air quality data gathering program consisted of the following studies published in References 58-61:

1. Parachute Creek Valley Diffusion Experiments - September 1972

2. Climate and Air Quality Analysis of the Parachute Creek Airshed, Garfield County, Colorado, January 1973

3. Climatology at Parachute Creek, April 1973

4. An Evaluation of Existing Air Quality Data Obtained at the Parachute Creek Site of the Semi Works Plant, July 1973

5. Atmospheric Dispersion of Airborne Effluents from the Roan Plateau, October 1973

6. Colony Development Operation (various internal studies)

The contractors on these programs were Thorne Ecological Institute, Battelle Pacific Northwest Laboratories, Dames & Moore, and CDM Environmental Consultants.

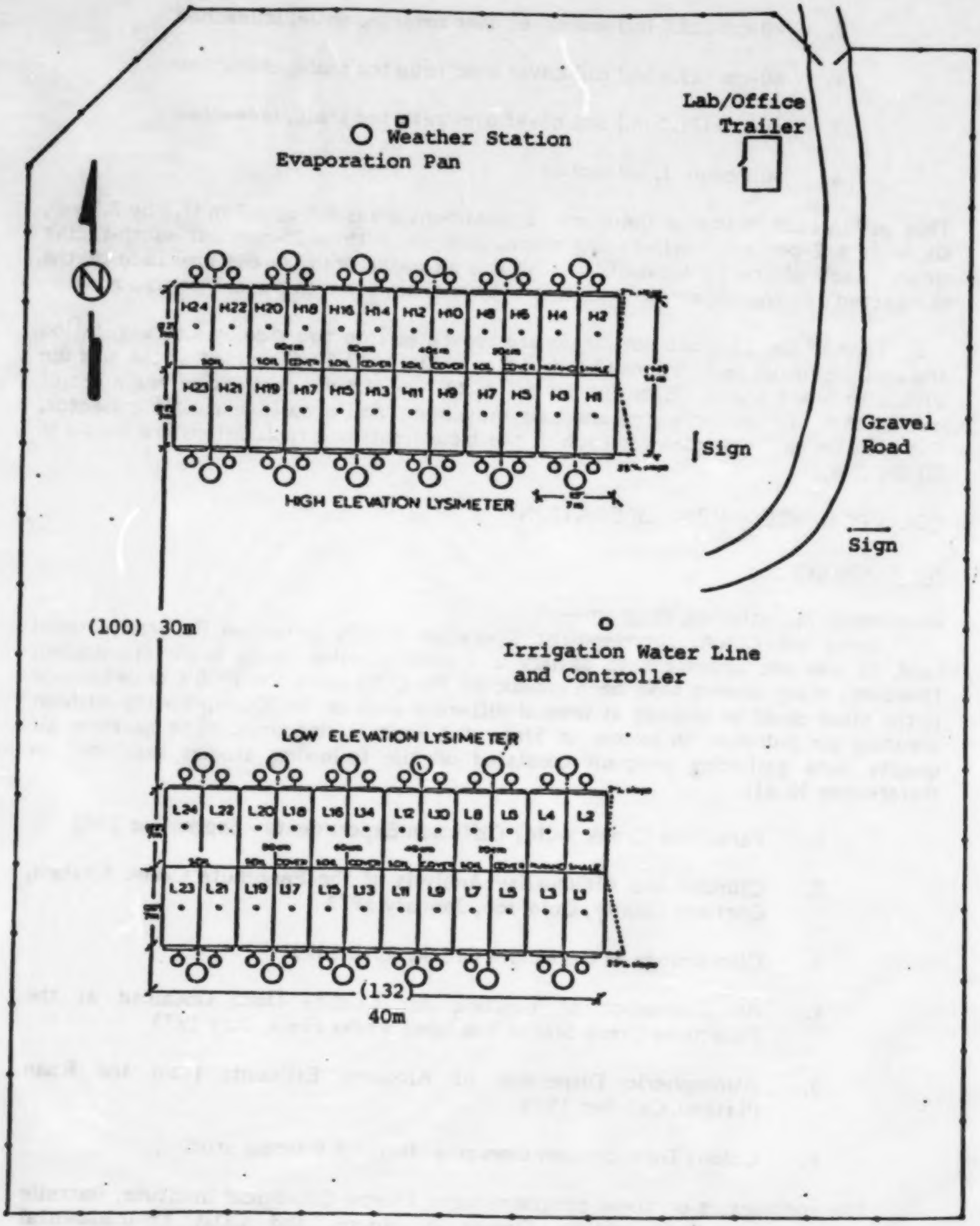
Lab/Office Trailer
Weather Station
Evaporation Pan
N
H24
H22
H20
H18
H16
H14
H12
H10
H8
H6
H4
H2
H23
H21
H19
H17
H15
H13
H11
H9
H7
H5
H3
H1
Sign
Gravel Road
HIGH ELEVATION LYSIMETER
Sign
(100) 30m
Irrigation Water Line and Controller
LOW ELEVATION LYSIMETER
L24
L22
L20
L18
L16
L14
L12
L10
L8
L6
L4
L2
L23
L21
L19
L17
L15
L13
L11
L9
L7
L5
L3
L1
(132)
40m

Figure C-41. Plot plan of lysimeter study site.

The climate and air quality analysis of the area--In mid-1969, CDO initiated a program of ambient air quality sampling in the Parachute Creek Laboratory site. This study lasted until the end of 1972. An analysis of the meteorology and air quality collected was described in a report prepared by Dames & Moore (59).

Similar programs were conducted afterwards, and they are being augmented in two more primary locations in the area. In October 1970, Dames & Moore operated a network of six mechanical weather stations (Stations 1-6 on Figure C-42) for approximately 14 months. The rest of the stations in Figure C-42 along the Parachute Creek Valley were operated for several months in the spring of 1972 by Thorne Ecological Institute. Analysis of selected features of the area based on the data collected in these stations was prepared for CDO by Dames & Moore and Thorne Ecological Institute (58,59).

The air quality program conducted in the above studies included continuous analyses for sulfur dioxide, oxides of nitrogen, total hydrocarbons, particulates, and the total sulfur content of the air. The program also included the recording of temperature, relative humidity, barometric pressure, wind, wind direction, precipitation, and solar radiation.

The continuous measurement of sulfur dioxide was performed by means of the Scientific Industries Model 67 Analyzer/Recorder. This instrument detects the presence of SO_2 by measuring the conductivity change in a known volume of electrolyte produced by impingement of a known volume of ambient air. The method of impingement of this particular instrument is such that interferences are minimized. Continuous measurement of total hydrocarbons was performed at Parachute Creek by means of the Beckman Instruments Model 400 hydrocarbon analyzer. This instrument detects the presence of hydrocarbons in four decade ranges from 0 to 10,000 ppm in the ambient air by the method of flame ionization. The continuous measurement of oxides of nitrogen at Parachute Creek was performed by means of the Beckman Model 909 NO analyzer. The instrument has three indicating ranges--0 to 0.2 ppm, 0 to 0.5 ppm and 0 to 1.0 ppm. Integrated 24-hr measurements of particulates were performed by means of the standard high-volume sampler. The high-volume samplers within Parachute Creek were regulated by timers to sample 15 min out of each hour. Periodic calibrations of the sampler flow rate indicators were performed before weighing both the exposed and unexposed filter paper. The total sulfur content of the air was determined at several locations by means of sulfation discs, whose active agent is PbO_2. This powerful oxidizing agent reacts readily with several sulfur-bearing compounds, including SO_2, SO_3, H_2S, sulfuric acid mist, mercaptans, and organic sulfides. The discs were exposed to the ambient air for a 30-day period and then sent to a commercial laboratory for analysis in accordance with well-defined procedures.

Field tracer studies--During the week of May 31 to June 6, 1972, an extensive field study was undertaken to determine the ventilation rate through the Parachute Creek Valley. This study (60) involving the measurement of diffusion of tracer particulates was conducted jointly with the CDO and Battelle Northwest Laboratories. Seventeen tracers were released during the 7-day experimental period. Fluorescent dye, sulfur dioxide, and silver iodide particles were released from various heights of the two towers. One of the towers was located on the Roan Plateau, and the other is at the confluence of the East Middle Fork and Middle Fork Valleys of Parachute Creek. Sampling of the fluorescent dye and the silver iodide

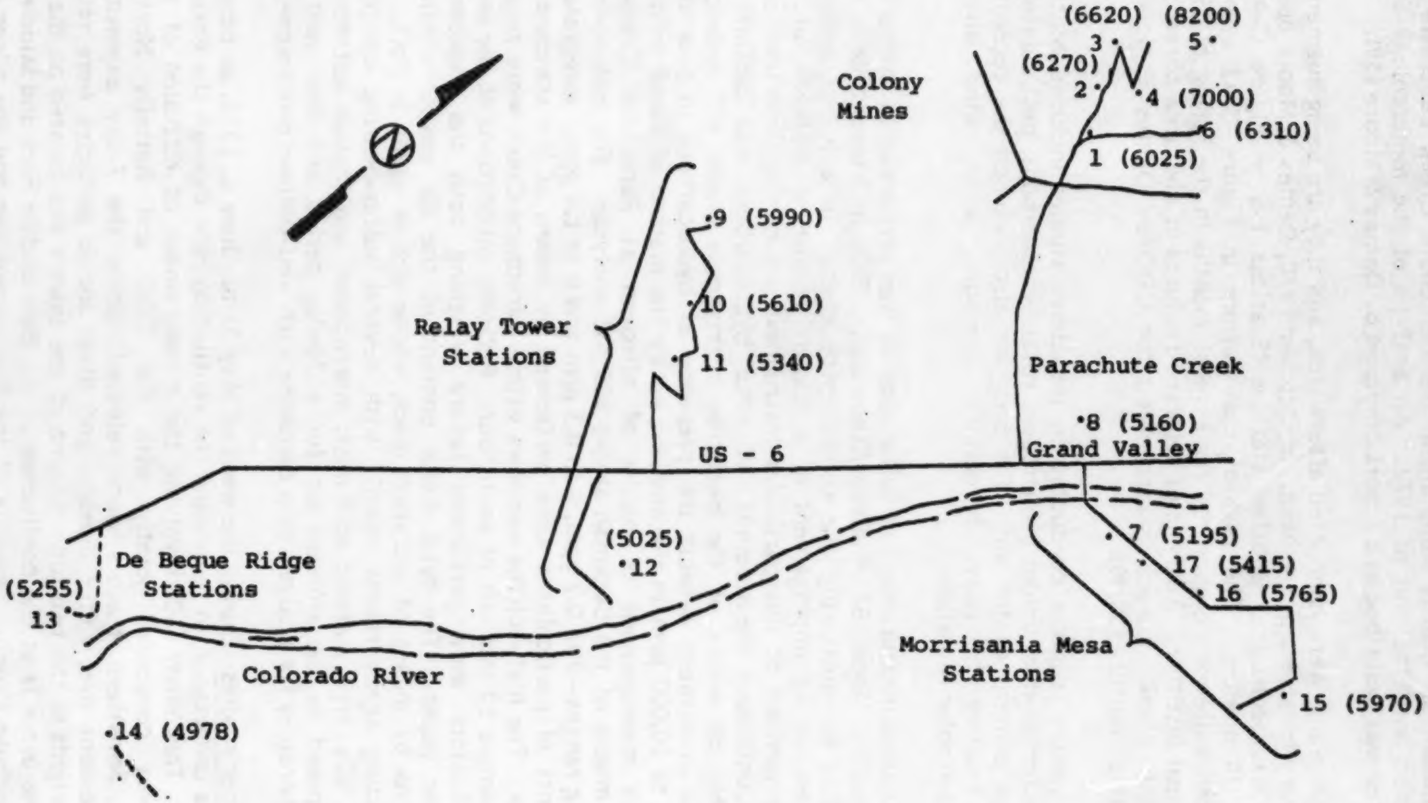
(6620) 3
(8200) 5
(6270) 2
4 (7000)
6 (6310)
1 (6025)
Colony Mines
N
9 (5990)
10 (5610)
11 (5340)
Relay Tower Stations
Parachute Creek
8 (5160)
Grand Valley
US - 6
(5025) 12
7 (5195)
17 (5415)
16 (5765)
De Beque Ridge Stations
(5255) 13
Morrisania Mesa Stations
15 (5970)
Colorado River
14 (4978)

Figure C-42. Location map for CDO primary weather station.

was performed with engine-driven vacuum pumps that drew air at a controlled flow rate through filters on which the particulates were collected. Sulfur dioxide sampling was accomplished with battery-driven, miniature pumps that bubbled air at a constant rate through a solution that retained the sulfur oxide. Thirteen other sampler systems were operated at the 18 sampling sites in the Valley. Only particulate samplers were operated at an additional 12 sites east and west of Grand Valley on U.S. Highway 24. Aircraft sampling of silver iodide was performed with an electro-optical ice-nuclei counter. The counts that are recorded on a strip chart as a function of time are converted to concentrations and correlated with aircraft positions for those times during analysis. Meteorological measurements such as temperature, wind velocity, and humidity were recorded at the two previously mentioned release towers and at a third. A rawinsonde unit was operated to obtain vertical profiles in and above the Valley on run nights.

For analysis, the fluorescent tracers were washed from the sample filters by a fixed volume of distilled water, and the fluorescence was measured with a G. K. Turner Associates fluorometer. The measured fluorescence was then converted to concentrations in air using the sampler flowrate. The sulfur dioxide samples were analyzed with a Technicon Autoanalyzer using the sulfamic acid variation of the West-Gaeke method.

Unfavorable conclusions from the above investigation resulted in another study, performed on the Roan Plateau. The location of the new site is indicated in Figure C-43, along with the release tower, whose location is shown by an asterisk. An onsite field experiment was conducted on seven consecutive days in the period of June 29 - July 6, 1973. It included the release and sampling of tracer material, the tracking of pibal balloons, the tracking of no-lift (constant density) balloons, and the operation of an aircraft to obtain definition of the temperature field over the region of interest. Meteorological data were recorded from three tower levels during this period.

The tracer used in the tracer experiments was Tracerite FP3206, which fluoresces green under ultraviolet light. The material was fluidized to assure free flow from the tower-mounted dispenser and separated into individual particles. The metering system was remotely controlled so that a constant emission rate could be maintained. The rotorod sampler was the device used to sample the air concentrations of tracer, and the samplers were mounted on wooden stakes at a height of about 150 cm (59.0 in.). Locations of the sampling positions used are shown in Figure C-43. Assay of the sample collector rods was performed by a visual count of the particles. The rod was mounted in a suitable holder on the mechanical stage of a microscope and was illuminated by ultraviolet lamps in an otherwise fully darkened room.

Pibal tracking--Pibals are small balloons that are ballasted to rise on the order of 150 m/min (492 ft/min) and to respond to the wind velocities that they encounter during the rise. Results of this operation were generally disappointing because of the difficulty in accurately locating the pibal at its first observation 30 sec after release.

Aircraft soundings--The aircraft soundings were invaluable in determining vertical temperature profiles at the site for comparison with Grand Junction rawinsonde temperature profiles.

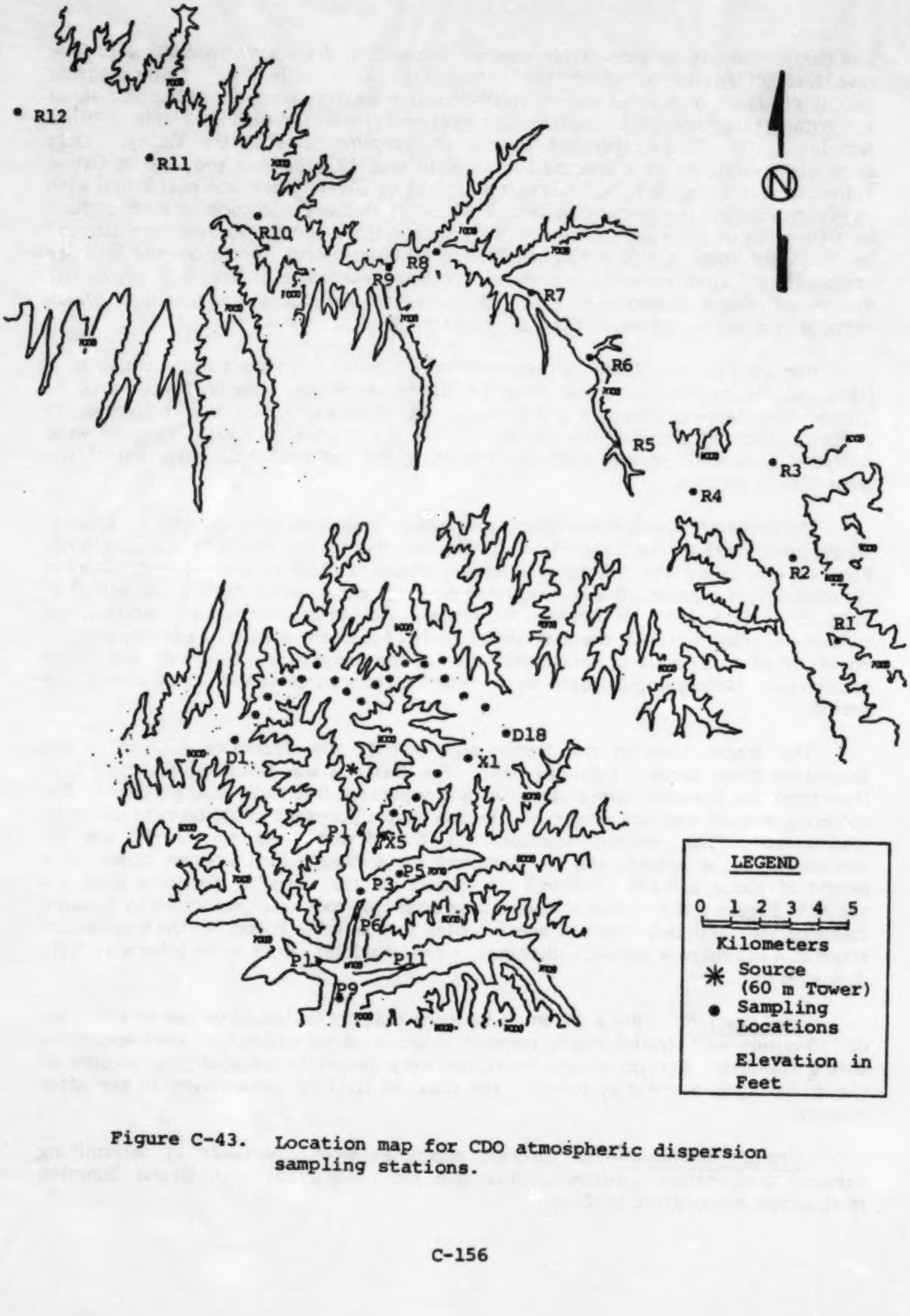
R12
R11
R10
R9
R8
R7
R6
R5
R4
R3
R2
R1
D18
D1
X1
P1
X5
P5
P3
P6
P1
P11
P9
LEGEND
0 1 2 3 4 5
Kilometers
✳ Source (60 m Tower)
● Sampling Locations
Elevation in Feet

Figure C-43. Location map for CDO atmospheric dispersion sampling stations.

Interim Monitoring Program--

While awaiting a favorable economic climate for commercial development, the CDO has ceased its semi-works mining and retorting operations. Since the last operation of the semi-works plant in 1972, the Parachute Creek environmental studies program has been maintained at a low level.

No publications are available that describe the monitoring program that has been implemented at the CDO since 1973. All information on this subject was supplied by Mr. Max Legatski, Coordinator for Permits and Water Contracts, and Mr. Larry Kline, Environmental Coordinator for the Atlantic Richfield Co. (ARCO).

Presently there are three meteorological stations operating on CDO property. Wind speed, wind direction, and temperature are recorded continuously. At two monitoring sites, particulate concentrations are monitored every 4 days. In addition, precipitation is being measured at Davis Gulch.

In addition to the field monitoring program, a number of studies have been recently prepared regarding environmental consequences of CDO commercial development. These studies include References 62-65.

Commercial Development Phase Monitoring Program--

Presently there are no detailed plans for a commercial operation monitoring program. The Colony Development Operation has agreed to conduct stack monitoring as part of permit requirements, but ambient monitoring is still not well defined. An official ambient monitoring schedule will be developed subsequent to agreement with EPA and the Local Air Pollution Control District.

Water Resources

Baseline Data Gathering Programs--

The baseline surface and groundwater data gathering programs were mainly conducted between 1972 and 1974. The project contractors were the Thorne Ecological Institute and Wright Water Engineers. The documents published on the subject include the Colony Environmental Study (58) and Water Studies, Parachute Creek, Colorado (66). The reports that have been discussed in these published documents and that have been utilized in the completion of this study include the following:

1. Water Quality of the Parachute Creek Ecosystem and the Impact of Possible Oil Shale Operations
2. Chemical Water Quality Characteristics of Parachute Creek
3. Preliminary Water Supply Strategy for One Oil Shale Plant in Parachute Creek Basin
4. Colorado River Salinity: Impact of Parachute Creek Oil Shale Plant and Alternatives for Mitigation
5. Moisture Level Investigation of the Colony Spent Shale Disposal Embankment, Parachute Creek, Garfield County, Colorado, July 1976

Surface water quality studies--One water quality study was conducted by Thorne Ecological Institute for CDO in 1973 (67). The purpose of this report was to define the water quality of Parachute Creek and its tributaries with regard to inorganic constituents. Data for the study were extracted from extensive water records in Colony files. For this reason, there were no data presented on frequency of sampling and analysis. The collecting stations from which data were gathered to be used in analyzing impacts were chosen to give a reasonably valid representation of the Parachute Creek Watershed. A map of these stations is presented in Figure C-44. The water quality parameters measured during the study are listed as follows:

Total dissolved inorganic solids
Total dissolved solids
Total anion or cation
SO_4
Na + K
$HCO_3 + CO_3$
Mg
Ca
Cl

Suspended solids
Turbidity
F
Ni
Hg
Pb
Cd
Fe

Al
Cu
Zn
Ca
Co
CO_2

Pyrite
Feldspar
Analcite
Clays
Quartz
Carbonates
Temperature
pH
Organic Toxicants
Inorganic Toxicants

Flow

DO
BOD
pH
EC
TDS
Ion balance

Mg
Ca
Na
SAR
HCO_3
CO_3

Cl
SO_4
NO_3
PO_4
SiO_2
F

Conductivity, pH, and dissolved oxygen were all measured in the field using commercially available meters and sensing probes (laboratory calibrated). Water for laboratory analysis was collected in acid-washed new polyethylene bottles. All samples were taken in duplicate, and analyses were run separately. Metals were measured using an AAS. Mercury was measured using a cold vapor atomic absorption spectrophotometer. All water analyses were performed in accordance with Standard Methods (37).

From September 1969 to August 1972, water samples were taken by CDO to determine the baseline chemical water quality characteristics of Parachute Creek (67).

Water quality analyses were run on samples taken from 12 stations in the Parachute Creek drainage basin and two stations on the Colorado River near the mouth of Parachute Creek. Streamflow measurements were made at three gaging stations operated by CDO. In addition, data were taken from records of three streamflow gaging stations operated by USGS. A map showing the locations of the CDO and USGS streamflow gaging stations is presented in Figure C-44.

Stream-flow data for USGS Stations 9-935, 9-930, and 9-928 are available for the years 1922-27, 1949-54, and 1958-62, respectively. Streamflow data for CDO Stations 551, 552, and 557 are available for June to September 1970 and August 1971 to June 1972.

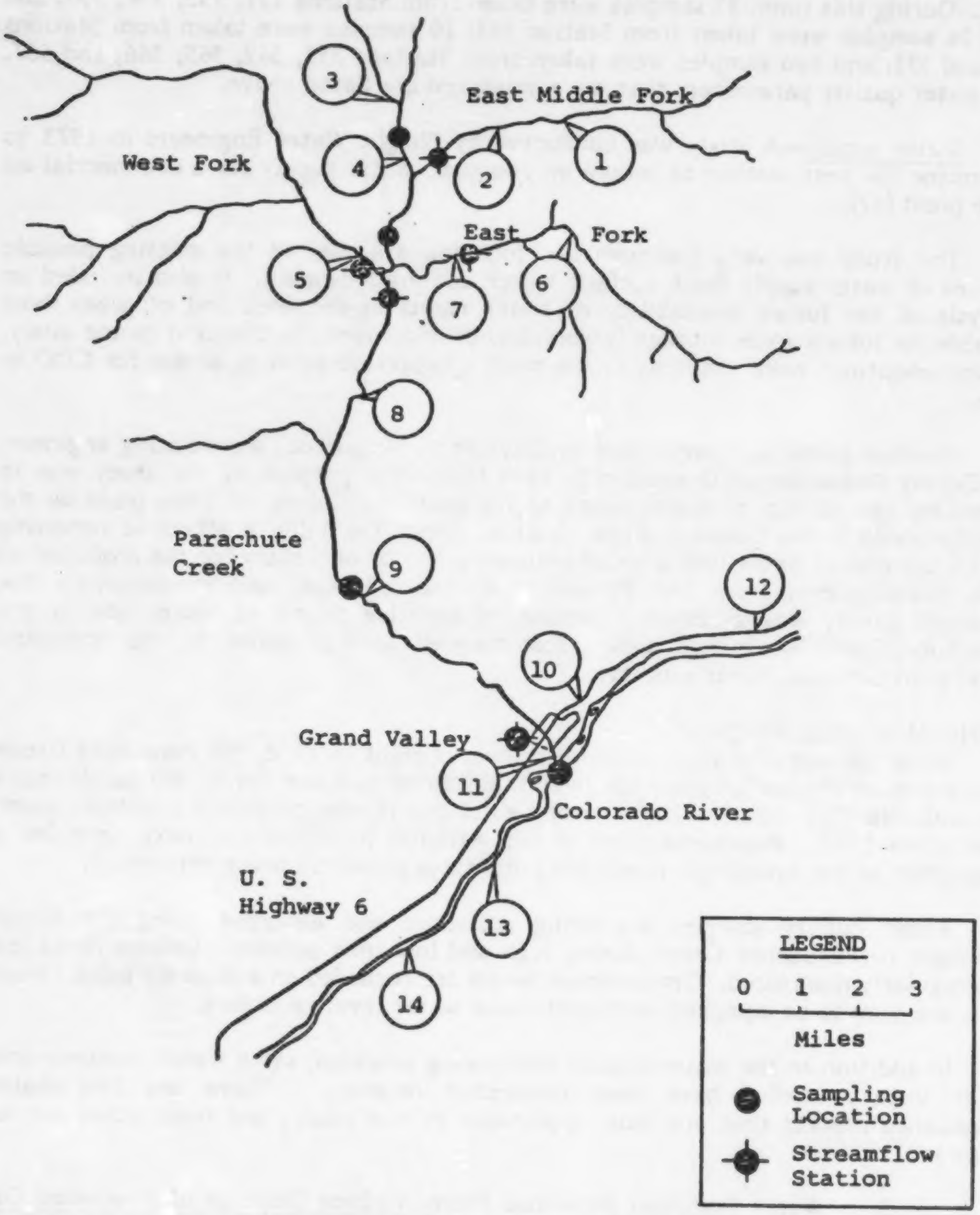
3
East Middle Fork
West Fork
4
2
1
East
Fork
5
6
7
8
Parachute
Creek
9
12
10
Grand Valley
11
Colorado River
U. S.
Highway 6
13
14
LEGEND
0 1 2 3
Miles
Sampling
Location
Streamflow
Station

Figure C-44. Location map for CDO and USGS water quality sampling stations.

Water quality samples were taken for the period September 1969 to August 1972. During this time, 37 samples were taken from Stations 551, 552, 554, 555, and 556; 26 samples were taken from Station 553; 10 samples were taken from Stations 557 and 591; and two samples were taken from Stations 558, 562, 565, 566, and 567. The water quality parameters that were measured are listed above.

Water supply--A study was conducted by Wright Water Engineers in 1973 to determine the best method to secure an adequate water supply for a commercial oil shale plant (67).

The study was very thorough and included a survey of the existing possible sources of water supply (both surface water and groundwater). It also included an analysis of the future availability of water rights in the area and of areas most suitable for future water storage (reservoirs) development. Subsequent to the study, recommendations were made as to the most appropriate form of action for CDO to take.

Another study was performed by Gaylard V. Skogerboa, a consulting engineer, for Colony Development Operation in 1974 (67). The purpose of the study was to determine the effects of water usage at the proposed Colony oil shale plant on the salinity levels in the Colorado River System. First, the salinity effect of removing 283 l/s (10 cfs) of water (the amount anticipated to be necessary for the proposed oil shale development) from the Parachute Creek drainage, and consequently the Colorado River, was assessed. Second, alternative forms of water use in the Parachute Creek watershed were recommended as mitigation to the projected increase in Colorado River salinity.

Interim Monitoring Programs—

Since the last operation of the semi-works plant in 1972, the Parachute Creek environmental studies program has been maintained at a low level. No publications are available that describe the environmental monitoring programs that have taken place since 1972. Representatives at the Atlantic Richfield Co. have provided a description of the hydrologic monitoring practices presently being performed.

Water quality samples are being collected and analyzed along the major drainages of Parachute Creek during high and low flow periods. Stream flows are also regularly monitored. Groundwater levels are recorded on a monthly basis. Four wells are soon to be equipped with continuous water level recorders.

In addition to the water quality monitoring program, some water resource and water impact studies have been conducted recently. There are two major unpublished reports that are most applicable to this study, and their titles are as follows:

1. Water Pollution Potential From Surface Disposal of Processed Oil Shale From the Tosco II Process; A Report to CDO. The Atlantic Richfield Co., Denver, Colorado, October 1975.
2. Reconnaissance Study, Middle Fork and Davis Gulch Dams, Colony Oil Project, Denver, Colorado, April 1924.

Commercial Development Phase Monitoring Program--

Presently there are no detailed commercial development phase monitoring program plans available for public inspection. The Atlantic Richfield Co. has stated that when commercial development proceeds, all State, local, and Federal legal stipulations will be met.

Biological Resources

Baseline Data Gathering Program--

In the period 1970-73, the Thorne Ecological Institute performed baseline resource studies for CDO. The studies included air, water, and biological resource monitoring programs, along with impact assessments of Colony's future development. To assure thoroughness, a summary baseline data gathering program has been provided for each project individually. CDO has, by far, provided the most information on local ecology and the environmental impact of development than any of the other private oil shale developers.

The reports that have been used in completing this report are published in two documents--the Colony Environmental Study (58) and Ecological Studies (68). The titles are as follows:

1. Vegetation Inventory and Impact Study of the Parachute Creek Area, Garfield County, Colorado;
2. Warm Blooded Vertebrates Inventory Analysis and Impact Study of the Parachute Creek Area, Garfield County, Colorado;
3. Lower Trophic Levels and Disease Vectors Inventory Analysis and Impact Study of the Parachute Creek Area, Garfield County, Colorado;
4. Annotated Checklist of Birds and Mammals Known to Occur in Northwestern Colorado;
5. Big Game Fencing and Underpasses;
6. Cold Blooded Vertebrates of Parachute Canyon, Garfield County, Colorado;
7. Competition Between Deer and Livestock;
8. Survey of 1972 Deer Season, Game Management Unit #32, Parachute Creek, Garfield County, Colorado;
9. Literature on Beaver and Their Relation to Stream Flow - Inventory of Beaver Ponds, East Middle Fork, Parachute Creek;
10. Movement of Mule Deer in Parachute Basin, Garfield County, Colorado, 1971 - 1972;
11. Preliminary Review of Literature and Effects of Air Pollution on Wildlife Habitat.

Each of these reports is discussed briefly in the following subsections.

Vegetation inventory and impact study--In 1971, a study was performed to determine in detail the vegetative resources existing in the Parachute Creek area of Garfield County, Colorado (58). Before any field investigation, a significant amount of time was spent in reviewing aerial photographs and topographical maps to become familiar with the area and to design an efficient sampling technique.

Field work was initiated in June 1971. Plants were first collected from a variety of habitats, identified, pressed for future reference, and listed. Transects were established using the nested quadrant technique (69). This technique utilizes 10 m (32.8 ft) on a side for the tree stratum, 4 m (13.1 ft) for the shrub stratum, and 1 m (3.3 ft) for the herbaceous stratum. The quadrants were established along set compass lines at 150 m (492 ft) paced intervals. These plots were established as permanent after the 1971 reconnaissance sampling program. The procedure followed during vegetation monitoring was as follows: All plant specimens were verified by William A. Weber of the University of Colorado Museum. In the laboratory, frequency for each species, density, cover, and height of each vegetation type was computed.

Warm-blooded vertebrate inventory analysis and impact study--Before any field work was done in the Parachute Creek Basin, a literature search was performed (68). Very little published information was available dealing with wildlife of the Parachute Creek Basin. The field work consisted of aerial and ground survey techniques and small mammal trapping. A standard management area statistical history analysis and some literature searches were also conducted.

General field observation techniques were used to identify the presence of bird species in the area. An impact evaluation of the project development on wildlife was conducted along with a study of recommended impact mitigation methods.

Lower trophic levels and disease vectors inventory analysis and impact study--Aquatic invertebrates and blood-sucking arthropods were inventoried along the Parachute Creek drainage areas at 14 locations in the summer of 1972 (58). The locations of the sampling sites for aquatic ecosystems is presented in Figure C-45. A Surber sampler was used to inventory aquatic invertebrates. A .09 m^2 (1 ft^2) area was disrupted, and all living residue was allowed to flow into the Surber net. Examination of the net contents, either alive or preserved in alcohol or formalin, permitted a determination of the number of animals in .09 m^2 (1 ft^2) of streambed. Since conditions change almost continuously along the course of a streamflow, the determinations made at each sampling site could only be considered valid at that site. Samples were obtained by hand at places that did not permit the use of the Surber sampler. A fine plankton net was used to sample true planktonic free-flowing forms and forms dislodged from the streambed. Approximately 40 l (10 gal) was allowed to run through the net during each sampling experiment.

Special collections were made for protozoa by collecting submerged plant materials or bottom samples. Collections were examined within a few hours. Cultivation of protozoa in culture dishes was also attempted.

Five fish were killed and examined for feeding habits. Random collections were made of biting arthropods such as mosquitos and deer flies. Information was

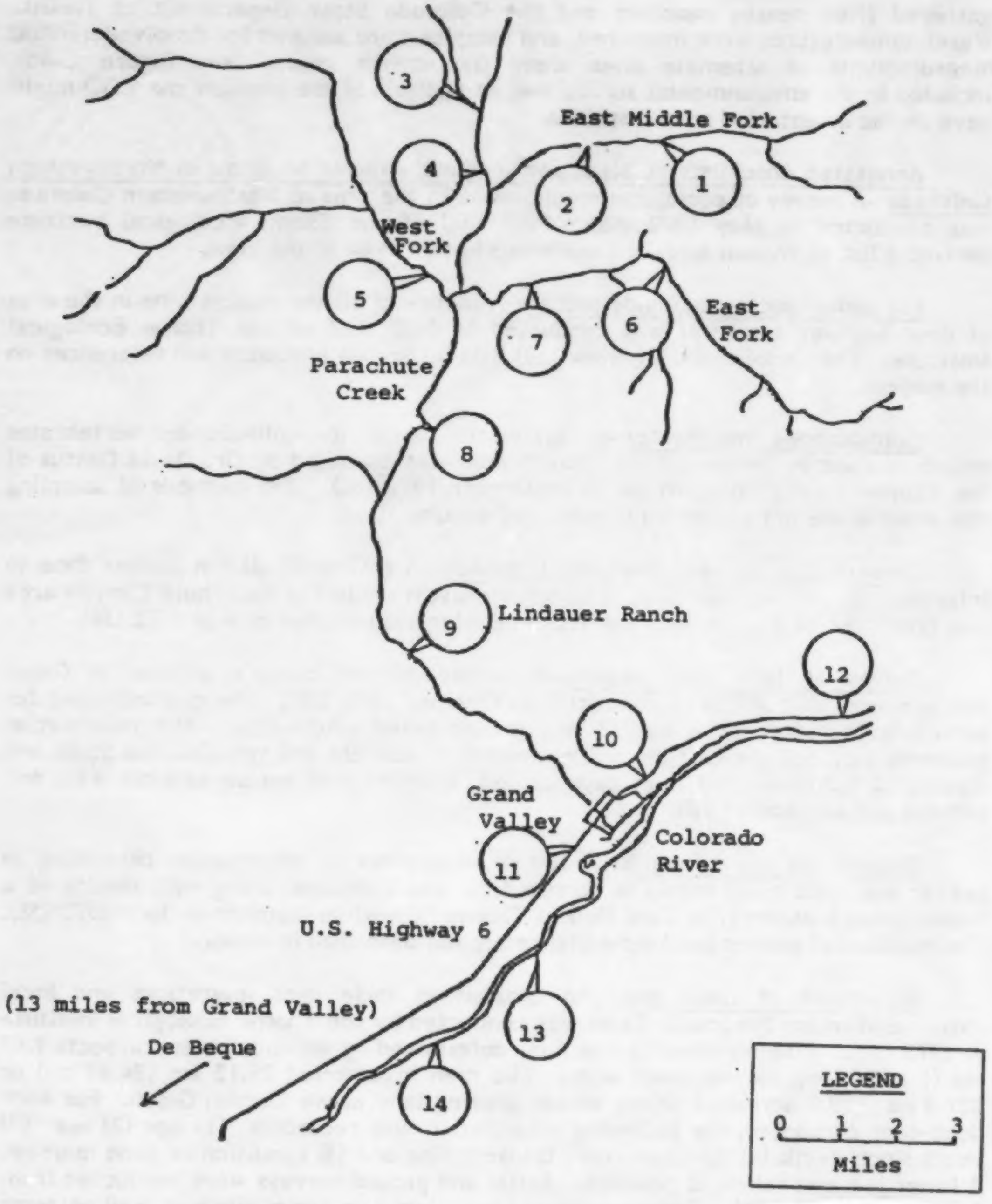
3
East Middle Fork
4
2
1
West
Fork
5
7
6
East
Fork
Parachute
Creek
8
9
Lindauer Ranch
12
10
Grand
Valley
Colorado
River
11
U.S. Highway 6
(13 miles from Grand Valley)
De Beque
13
14
LEGEND
0
1
2
3
Miles

Figure C-45. Location map for CDO aquatic ecosystem sampling sites for the baseline biological resource monitoring program.

gathered from nearby ranchers and the Colorado State Department of Health. Water temperatures were measured, and samples were secured for dissolved mineral measurements at alternate sites along the stream course (see Figure C-45). Included in the environmental survey was an analysis of the impacts the CDO might have on the inventoried animal species.

Annotated checklists of birds and mammals known to occur in Northwestern Colorado--A survey of ecological studies done in the area of Northwestern Colorado was conducted in May 1972 (58). Paul Neil of the Thorne Ecological Institute derived a list of various birds and mammals known to be in the area.

Big game fencing and underpasses--A review of all the studies done in the area of deer highway fatalities was conducted by Paul Neil of the Thorne Ecological Institute. The October 1972 review (58) lists all known abstracts and references on the subject.

Cold-blooded vertebrates--A description of all the cold-blooded vertebrates known to exist in the Parachute Canyon area was compiled by Dr. David Dettus of the Thorne Ecological Institute in September 1972 (58). The methods of sampling and analysis are not presented in published documents.

Competition between deer and livestock--A review of all the studies done to interpret the competition between deer and livestock in the Parachute Canyon area was presented by Paul Neil of the Thorne Ecological Institute in May 1972 (58).

Survey of 1972 deer season--A survey of the hunter's actions in Game Management Unit #32 was conducted in October 1972 (58). The methods used for surveying included aerial survey and ground-based interviews. The information gathered included the camp location, number of hunters and vehicles, the State and County of hunters, total man days hunted, frequency of return to Unit #32, and harvest and location of kill.

Beaver and beaver ponds--A list of references on information pertaining to beaver and their relationship to stream flow was compiled, along with results of a beaver pond inventory, by Paul Neil of Thorne Ecological Institute in June 1972 (58). The methods of beaver pond surveillance are not described in detail.

Movement of mule deer--An analysis of mule deer migrations and local movements in the Parachute Basin was conducted by the Thorne Ecological Institute in 1972 (58). Winter mortality was first determined by walking linear transects 1.67 km (1 mile) long by one chain wide. Two men inventoried 39.12 km (24.45 mi) or 121.3 ha (299.7 acres) of prime winter grazing land above Garden Gulch. For each dead deer contacted, the following information was recorded: (1) age (2) sex (3) years since death (4) distance from transect line and (5) condition of bone marrow. A lower jaw was taken, if possible. Aerial and ground surveys were conducted from January to April 1972. Special emphasis was placed on aerial views of trail patterns and ground views of tracks, scat and actual presence of deer.

Effects of air pollution on wildlife habitat--A review of all available literature dealing with the effects of air pollution on plants and animals has been conducted by Thorne Ecological Institute (58). The review included a summary of the literature and some concluding comments as to the possible air pollution effects of the CDO on existing air quality.

Interim Monitoring Program—

The monitoring program that has been instituted by the CDO in the interim period between baseline data gathering and commercial development phase monitoring includes limited monitoring of biological resources. CDO has conducted big game counts during the interim monitoring phase and compiled a list of endangered plant species (68).

Commercial Development Phase Monitoring Program—

No outline has been published for a commercial development phase biological resource monitoring program at the Colony Development. CDO has stated, however, that they will comply with all Federal, State, and local monitoring requirements when commercial development operations are conducted.

Solid Wastes Disposal, Revegetation

Baseline Data Gathering Program—

Since 1965, many studies have been published on the disposal of solid wastes generated in the production of oil shale at the CDO. Because the main source of solid waste from this production would be in the form of spent shale, all of the published studies either address the revegetation capabilities of processed shale or possible alternative methods of large-scale solid waste disposal. The reports that have been published on revegetation of processed shale at CDO have been published in Environmental Impact Assessment at Colony Development Operation (70). Their titles are as follows:

1. 1965 Denver Field Experiment
2. Some Properties of Spent Oil Shale Significant to Plant Growth
3. Greenhouse Experiments of Plant Growth in Processed Shale
4. 1967 Field Experiments at Parachute Creek
5. 1968-69 Semi-Works Plot Field Experiment
6. Vegetation Establishment Demonstration (1971) on TOSCO II Processed Shale
7. Performance of Plants with Minimal Treatment of Processed Shale: An Interim Report
8. 1973 Annual Revegetation Report
9. Growing House Plants in Processed Shale
10. Chemical Analyses of TOSCO II Processed Shale and Their Interpretation Relative to Plant Growth
11. The Cost of Processed Shale Revegetation

12. Estimated Water Balance of Davis Gulch: For Present Conditions and After Use for Processed Shale Disposal

Reports addressing other aspects of massive solid waste disposal at CDO were published in Environmental Impact Assessment at Colony Development Operation (71). Their titles are as follows:

1. Uses of Spent Oil Shale Ash
2. Processed Shale Embankment Study
3. Proposed Shale Backfilling (Phase I)
4. Liquefaction Studies: Proposed Processed Shale Disposal Pile, Parachute Creek, Colorado
5. Slope Stability Studies: Proposed Process Shale Embankment, Parachute Creek, Colorado

The locations of all the revegetation sites developed by the CDO on the Dow property are presented in Figure C-46. The revegetation studies cited above are discussed briefly in the following subsections.

1965 Denver field experiment--Six test plots were constructed with dimensions of .9 x .9 x .2 m (3 ft x 3 ft x 8 in.) (70). The six plots were filled to a 15 cm (6-in.) depth with the following material:

Plot 1: 100 percent pure retorted shale

Plot 2: 100 percent pure retorted shale mixed with Platte River sandy bottom clay

Plot 3: Sandy clay soil

Plot 4: 100 percent processed shale

Plot 5: (Same as Plot 2)

Plot 6: (Same as Plot 3)

The plots were thoroughly wetted and mixed, planted, watered, and covered with a moist burlap. Measurements were made of germination rate, root growth, stem growth, drought resistance, and soil erosion.

Some properties of spent oil shale significant to plant growth--Two spent shale samples, one from the TOSCO II process and one from the USBM gas combustion process, were analyzed for properties significant to plant growth. In addition, two shale/ash byproduct materials were analyzed, both from the TOSCO pilot plant near Denver.

The analyses performed and the methods are listed below:

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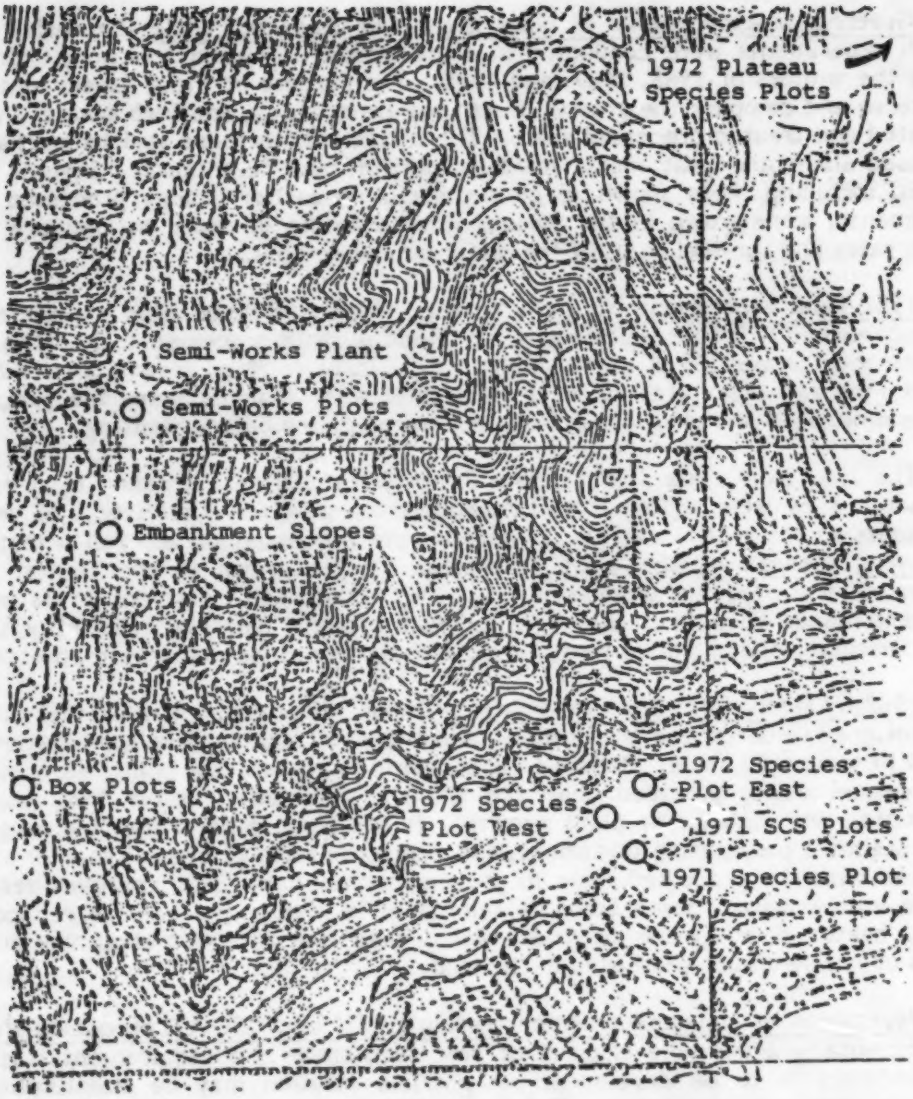

1972 Plateau
Species Plots
Semi-Works Plant
Semi-Works Plots
Embankment Slopes
Box Plots
1972 Species
Plot West
1972 Species
Plot East
1971 SCS Plots
1971 Species Plot

Figure C-46. Colony revegetation plots, Dow Property,
Garfield County, Colorado.

Analysis	Method
Fertility	Colorado State University Soils Test Lab
Salinity	Colorado State University Soils Test Lab
Available Nutrients	Sodium bicarbonate
Fe, Zn	Diethylenetriaminepentaacetic acid pressure
K	Ammonia acetate procedure

Greenhouse experiments of plant growth in processed shale--Extensive plant growth experiments were conducted in a greenhouse in Grand Junction, Colorado, during the winters of 1968, 1969, and 1970. The purpose of these experiments was to observe and compare the growth of various grass, shrub, and forb species in both untreated and treated processed shale. The treatments included various mixtures of processed shale and peat moss, sawdust, perlite, and fertilizers. Several plant species, including those shown to be successful in earlier Colony processed shale experiments, were grown in the various growth media in order to compare plant growth rates and survival rates of the different treatments.

1967 field experiments at parachute creek--The Denver field experiment in 1965 established that four species of grass would grow in processed shale. The later 1966 study on properties of spent oil shale significant to plant growth obtained good growth with tall wheatgrass when excess salts were leached from the processed shale and nitrogen and phosphorus fertilizer were applied before planting.

The 1967 field tests at Parachute Creek were carried out near Grand Valley, Colorado. They were designed to determine more precisely the effects of various treatments on the growth rates of grasses in pure processed shale. Tall wheatgrass (*Agropyron elongatum*, the most successful species grown in the Denver field experiment) was used, and evaluations of the effect of each treatment on its growth rate were made. Effects of variations in depth for seed planting, types of artificial cover, fertilizer and chemical treatments, and degrees of watering were observed.

1968-69 semi-works field experiment--Experiments during the summer of 1968 were designed to determine the optimal land treatments to achieve germination and growth in processed shale. Previous experiments indicated that plants grow readily in processed shale, provided that the shale is treated in ways that improve germination and subsequent plant growth. It has been learned that leaching is a highly desirable preplanting treatment, and that some form of organic matter should be mixed with the processed shale to prevent compaction. This improves aeration and prevents erosion. Some form of soil cover is highly desirable to reduce the surface heat. Four species of grass with a high tolerance for alkalinity and 10 species of native shrubs were used in the study.

Vegetation establishment demonstration (1971) on TOSCO II processed shale--Environmentally acceptable disposal of processed shale is a requirement if an oil shale industry is to be developed. A possible solution may be stabilization of processed shale with vegetation. Colony has been working since 1965 on TOSCO II processed shale as a plant growth medium in applied field and greenhouse studies (72,73) and in laboratory and greenhouse research (70). These studies have shown that processed shale can be used successfully as a plant growth medium if the excess salts are leached out and nitrogen and phosphorus fertilizer are added.

In light of the fact that existing plots have been self-sustaining for 5 years (through the 1977 drought) it seems obvious that revegetated shale areas can be maintained under natural precipitation. The potential cover will depend, among other factors, on the aspect, slope, and elevation of the disposal site and on the chemical and physical properties of the processed shale. This demonstration attempted to answer these questions.

Performance of plants with minimal treatment of processed oil shale: an interim report--This study describes and discusses observations after a 2-year period of a test planting on various TOSCO II processed shale mixtures. Evaluations were made of 15 species of grasses and shrubs and two transplant operations of 12 species of woody plants. All materials were planted in adjacent plots with fertilizer and mulch in three treatments: pure processed shale, halfshale/half-soil, and native soil. No water was applied. Results from seeding indicate very little survival on pure shale, mixed success on the 50/50 mixture, and excellent survival, vigor, and growth on native soil. Three species of shrubs (New Mexico locusts, New Mexico foresturia, and Russian olive) showed better than 50 percent survival on the pure processed shale. Other species showed lower survival rates. Survival on the other treatments was about double that on processed shale alone.

1973 annual revegetation report--The information presented in this report is based on work accomplished during the period January 1 to September 12, 1973. It is organized chronologically by project, and each project is identified by a name. A brief history of each project is given along with the summary of results for the year.

The initial box plots, established in 1967 to study the growth response of plant species in the processed shale, were planted with brome grass, tall wheatgrass, perennial ryegrass, crested wheatgrass, and Kentucky bluegrass, as well as several shrub species. A map was made of the plot and the location of each plant was plotted.

Established in 1968, the semi-works plots were designed to test a variety of species and various types of mulch. The species surviving from the original planting responded well to the 1972 application of fertilizer and irrigation.

Embankment slope plots were established in 1972 on the disposal embankment near the semi-works plant for the evaluation of the effectiveness of various mulches in the stabilization of processed shale slopes. The species used in this study consisted of a mixture of Indian ricegrass, annual ryegrass, yellow sweetclover, and russian wildrye, applied at the rate of 44.8 kg/ha (40 lb/acre).

The design and evaluation of 1971 species plots is presented in an article that discusses the various treatments involved. This evaluation notes that the percentage cover (by visual estimate) of pubescent wheatgrass and tall wheatgrass increased significantly during the period 1971-73 and that crested wheatgrass, although increasing, did so to a smaller degree. The rest of the species remained much the same as observed in 1972, with the exception of the forb mixture plot, which decreased from 80 to 5 percent cover. This sudden decrease is presumed to be due to overseeding the plot with biennial sweetclover which did not reseed itself. The fourwing saltbush showed heights up to 101.6 cm (40 in.), most of which was the current season's growth. Of the other shrub species in the plot, all were still alive, with the exception of two junipers that seem to have been unable to compete with the dense grass cover.

The 1971 SCS plots were set up to test the performance of plant species in the following treatments: 100 percent processed shale, 50 percent processed shale and 50 percent native soil, and 100 percent native soil.

The 1972 species plots, located in the East Middle Fork area, are two replications of the following treatments: 100 percent processed shale, 50 percent processed shale and 50 percent native soil, 15.2 cm (6-in.) and 61.0 cm (2-ft) cover of native soil over processed shale, and 100 percent native soil. All treatments were mulched with a wood hydro-fiber compound. Of the 14 species used in this study, the most successful have been fourwing saltbush, alkali sacaton, desert molly, crested wheatgrass, and Russian wildrye.

The 1972 plateau species plots were established on the plateau above Parachute Creek Canyon during the summer of 1972. Half of the plots were planted in the fall of 1972, and the other half were planted during the spring of 1973. The three treatments in this study were 100 percent processed shale, 15.2 cm (6-in.) cover over processed shale, and 100 percent native soil. The plots received uniform applications of nitrogen 78.6 kg/ha (70 lb/acre) and phosphorus 673.9 kg/ha (600 lb/acre), but only half of each plot was watered.

Growing houseplants in processed shale--Two studies were undertaken to determine the feasibility of growing house plants in oil shale treated by the TOSCO II process. In the first study, 18 varieties of house plants were grown in four different potting mixtures using the processed shale in varying proportions from one-ninth shale to pure shale. Based on the results of the first study, a second study was undertaken using the processed shale in higher percentages.

Chemical analysis of TOSCO II processed shale--This report analyzes the results of soil test data of TOSCO II processed shale between 1968 and 1972. These data are from samples taken during the various vegetation studies described in this volume. These studies include the 1968 and 1969 experimental plantings at Parachute Creek and samples of processed shale used in the greenhouse and laboratory and studies (some properties of spent oil shale significant to plant growth, and greenhouse experiments of plant growth in processed shale).

Two sources of soil test information were evaluated. First were samples submitted to Agricultural Consultants Laboratory (Ag Con Lab), and second were results of analyses reported in some properties of spent oil shale significant to plant growth. Results of soil tests with a do-it-yourself test kit were omitted from the following analysis, as no correlation was available between the results and plant growth. Use of soil tests on non-soil substrates often has its limitations, but the results appear to be satisfactory (although, as discussed later, the organic matter determination is probably of no value). Methods used by both sources of soil test information are standardized and have been correlated with plant establishment and growth on neutral or calcareous soils.

Estimated water balance of Davis Gulch--CDO (Atlantic Richfield Co., Operator) has intensively studied the problem of developing an environmentally acceptable commercial oil shale development utilizing the TOSCO II process.

Establishment of vegetation offers the most acceptable method of stabilizing the disposal areas and keeping erosion and leaching to a minimum. Recent environmental analyses also indicate that Davis Gulch is the most probable site for processed shale disposal.

The purpose of this study is to provide an estimate of the water balance relationships for the Davis Gulch watershed for present conditions, during revegetation, and during long-term establishment of permanent vegetation on the processed shale disposal area. An estimate of the irrigation water required for leaching and rapid vegetation establishment is also provided.

Uses of spent oil shale ash--This report reviews the three alternative methods of spent shale disposal and evaluates the technical and economic aspects of the third alternative--using the spent shale ash for some useful purpose such as construction material.

Processed shale embankment study--The CDO semi-works plant produced approximately 50,000 tonnes (55,000 tons) of processed shale between startup in the spring of 1971 through the time of the report, most of which had been placed in an embankment south of the plant in the Middle Fork Canyon. Construction of the embankment provided an opportunity to examine the applicability of conventional hauling, placement, and compaction equipment in handling processed shale. Material discharged from the plant conveyor was hauled by an elevating scraper and spread in 30.5 to 45.7 cm (12- to 18-in.) lifts for the compacting. Frontal or down-canyon slope was set as three horizontal to one vertical; side slope varied to permit examination of stability limits in the noncritical zones. The toe of the embankment forms the rear edge of a settling basin intended as catchment for potential runoff from natural precipitation. The lateral periphery of the embankment consists of a dike constructed of mine run shale to channelize potentially heavy runoff flows from the Middle Fork and Davis Gulch drainages away from the pile and to inhibit the erosion of processed shale. In addition to the original scope of this study, necessity dictated use of the disposal pile for retort sludge oil, sour water, catchment sump dredgings, and the extremely varied shale discharges from "processed shale wetter" development. Likewise, circumstances demanded operation during and following inundation resulting from line or ditch failure in the plant area above and four significant rainfalls. Experience gained under these unusual conditions will prove valuable in defining operational procedure and equipment for a commercial embankment.

Proposed shale backfilling (Phase I)--This report discusses the results of a preliminary investigation on the effects of placing high-temperature, processed oil-shale backfill inside the CDO oil shale mine located near Parachute Creek, Colorado. The primary purpose of this investigation was to provide a preliminary evaluation of the effects of the backfill on the fire hazard potential in the mine and on the temperature of an overlying groundwater aquifer. The preliminary backfilling plan would involve placing a major portion of the backfill in the mined-out headings with large trucks. Backfill in the upper portion of these headings, where overhead clearance would prohibit the use of trucks, would be placed pneumatically. The shale backfill would be placed soon after processing, and the temperature of this material is expected to be on the order of 93.3°C (200°F). For the investigation, backfill temperatures ranging from 93.3 to 204.4°C (200 to 400°F) were considered.

Liquefaction studies: Proposed process shale disposal pile, Parachute Creek, Colorado--This report summarizes the studies done on TOSCO II processed shale. The studies were conducted to determine the liquefaction potential of the material when stored in large quantities, as will be the case in the proposed processed shale pile disposal system.

Slope stability studies: Proposed process shale embankment—This report summarizes the results of tests that have been conducted to determine the slope stability of TOSCO II processed shale disposal piles.

Interim Monitoring Program—

During the interim monitoring program, periodic analyses of revegetated shale pile success are performed on a regular basis to compare with data gathered during the baseline program. This information is not published, however.

Commercial Development Phase Monitoring Program—

Determination made during the baseline and interim programs will allow for the design of an efficient commercial phase processed shale revegetation program.

Noise

No noise monitoring projects have been established in the baseline or interim monitoring programs. However, CDO has stated its intention of conducting noise monitoring to comply with all Federal, State, and local requirements at the start of commercial development.

Radioactivity

Radioactivity at the CDO has not been monitored during the baseline or interim programs, and there is no proposed program for its monitoring during commercial development. This determination applies to the areas of ambient air, surface water, groundwater, and soils.

Surface Subsidence

No subsidence tests have been conducted in the baseline or interim monitoring programs at CDO. However, CDO has stated that upon initiation of commercial development, any programs required by Federal, State, or local regulations will be implemented.

BX (EQUITY) OIL SHALE PROJECT

Information on environmental monitoring programs at the BX (Equity) Oil Shale Project was gathered from the BX Environmental Research Plan and from review with the project's environmental consultants, VTN in Irvine, California (74).

Air Resources

Air Quality—

Background air quality at the BX Oil Shale Project locations was determined by the Tract C-a and C-b baseline air quality programs. Since the three projects are basically in the same air basin, the ambient air quality is expected to be identical. Stack sampling parameters and methodology will be determined based on process evaluation and regulatory agency recommendations.

Meteorology--

One mechanical weather station was constructed to take wind speed, wind direction and temperature readings at 10-m (33 ft) elevation. On a ridge southeast of the site, a 30.5 m (100 ft) meteorological tower was erected. It is intended to measure temperature, wind speed and direction, and sigma at the 305 m (100-ft) level, and difference in temperature with the 30.5 m (100-ft) reading at the 10 m (33-ft) level. Data will be reduced to hourly averages and monthly frequency distributions for windflow. Temperature will be reduced to hourly averages.

Estimates of air pollution from the project's development were also made as part of the air quality studies.

The locations of all air resource monitoring stations are illustrated in Figures C-47 and C-48.

Water Resources

Water quality and flow measurements will be taken at two sites upstream and downstream of the Equity site on Black Sulfur Creek (sites ES-2 and ES-3 on Figure C-48). Monthly measurements will be taken of pH, conductance, temperature, and flow. Field analysis has been conducted weekly, and laboratory analysis has been conducted monthly since April 1978. During the operational phase, upstream water will be sampled monthly; downstream samples will be taken weekly during the first quarter, bi-monthly the second quarter, and monthly thereafter. Flow will be determined using the Parshall flumes installed by Equity. A list of the water quality parameters to be measured in this program is presented in Table C-36. Regional baseline water quality has been determined by evaluation of Tract C-a and Tract C-b USGS and State reports.

Depending on the completion date of the operational phase, a quarterly water quality analysis program will be implemented after the termination of operations.

The deep wells (BX-8 and BX-13 on Figure C-48) entering the Evacuation Creek Member and leached zone will be sampled four times during the quarter preceding the operational phase. Operational sampling and analysis will be done on a weekly basis for the first quarter, bi-monthly during the second quarter, and monthly thereafter.

In the alluvial wells (see Figure C-48), conductance, water levels, and pH will be determined monthly. If a 25-percent change occurs in any of these parameters, water quality tests indicated in Table C-36 will be conducted.

Biological Resources

Black Sulfur Creek will be surveyed to determine the condition of aquatic biota existing on the Equity property. Substrata samples will be collected upstream and downstream of the project using Surber samplers and Eckman dredges. Sampling will be performed three times a year during the operation phase (late winter, late

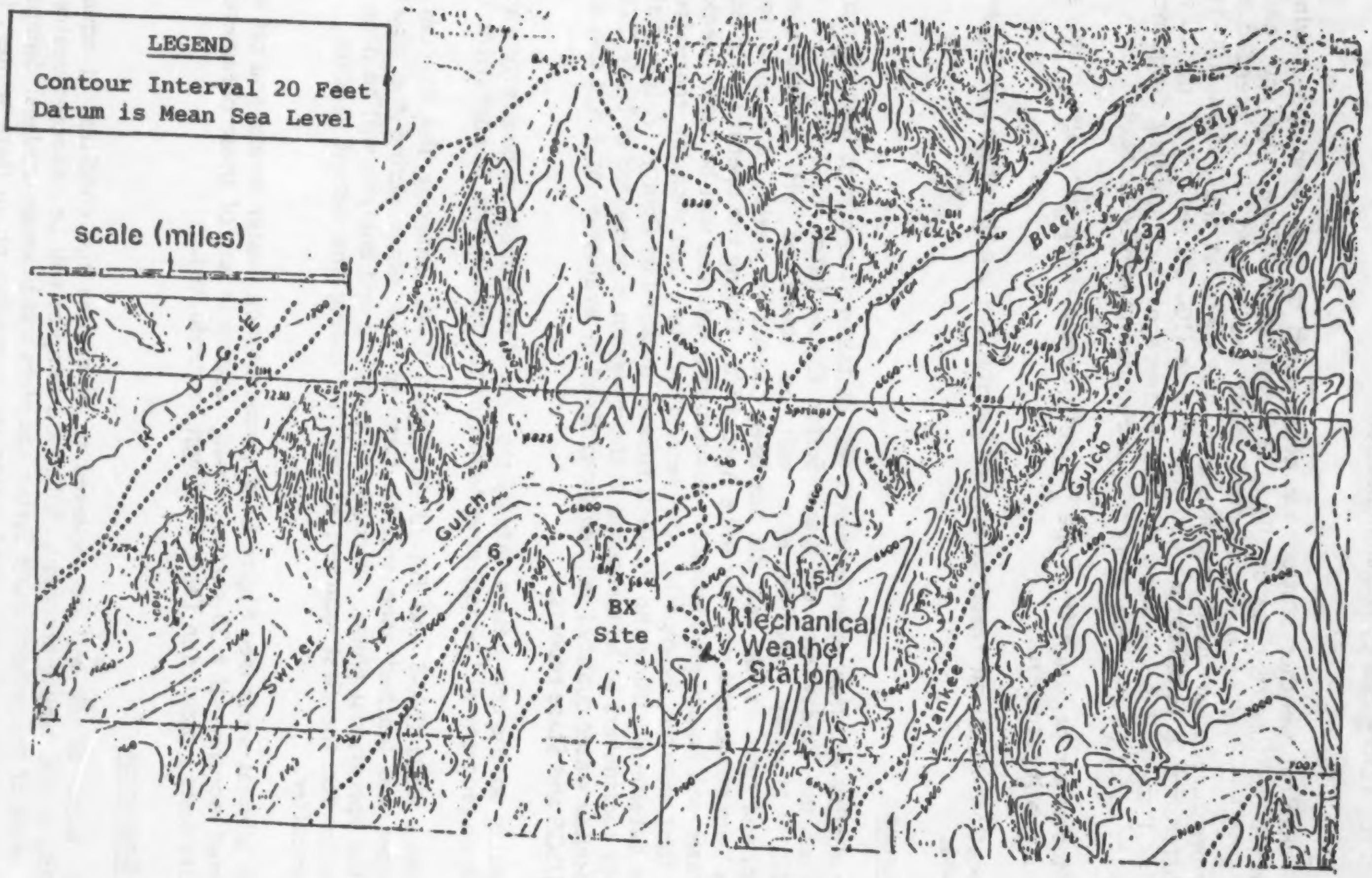

LEGEND
Contour Interval 20 Feet
Datum is Mean Sea Level
scale (miles)
Black
Gulch
33
32
9
6
15
Springs
Gulch
BX
Site
Mechanical
Weather
Station
Yankee
Swizer

Figure C-47. Location map for BX (Equity) oil shale project and mechanical weather station.

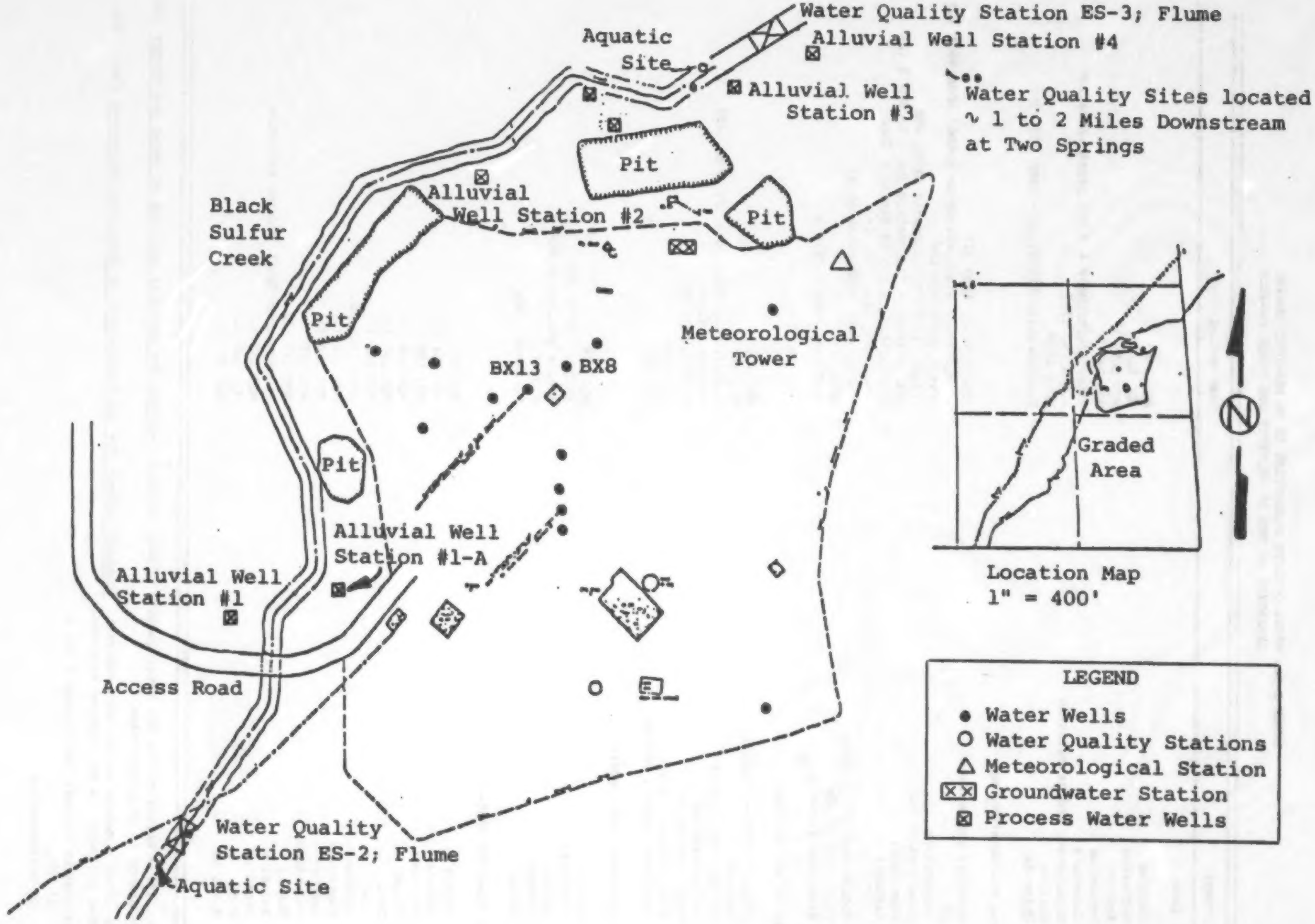

Water Quality Station ES-3; Flume
Alluvial Well Station #4
Aquatic Site
Alluvial Well Station #3
Water Quality Sites located ∿ 1 to 2 Miles Downstream at Two Springs
Pit
Pit
Black Sulfur Creek
Alluvial Well Station #2
Pit
Meteorological Tower
BX13
BX8
Pit
Alluvial Well Station #1-A
Alluvial Well Station #1
Access Road
Water Quality Station ES-2; Flume
Aquatic Site
Graded Area
N
Location Map
1" = 400'
LEGEND
● Water Wells
○ Water Quality Stations
△ Meteorological Station
☒☒ Groundwater Station
☒ Process Water Wells

Figure C-48. Location map for BX (Equity) air resources and water resources monitoring site.

TABLE C-36. WATER QUALITY PARAMETERS TO BE MEASURED DURING OPERATION OF THE BX (EQUITY) OIL SHALE PROJECT

Constituent	Test method
Major Ions:	
Calcium	WQO 103[a]
Magnesium	WQO 114
Sodium	WQO 147
Potassium	WQO 143
Carbonate	Glass electrode P & M end point titration
Bicarbonate and calculation	ALPHA 293 (2)[b]
Sulfate	APHA 493B
Chloride	Electrometric titration - APHA 302 (2)
General characteristics:	
Specific conductance	(Field Test) APHA (2)
pH	(Field Test) Glass electrode method APHA 460A (2)
Temperature	(Field Test) WQO 286
Dissolved oxygen	(Field Test) Polarographic APHA, 450
Alkalinity	(Calculated) - Titrimetric (pH 4.5) WQO 3 (2)
Hardness	(Calculated) - Sum of Hardness Ions WQO 103, 114, 110 (2)
Sodium Absorption Ratic	(Calculated) USDA Handbook 60
Dissolved solids	APHA 92 (2)
Suspended sediment	USGS TWRI Book 5 CPTC 1
Nutrients and organics:	
Chemical oxygen demand	WQO 20
Ammonia	WQO 159
Nitrate and nitrite	Specific Ion Electrode (2) APHA, 422
Orthophosphate	Mo-blue WQO 249
Total phosphate	Mo-blue WQO 249
Total organic carbon	WQO 236
Dissolved organic carbon	WQO 236
Trace Elements (Non-Metals):	
Silica	WQO 274
Fluorida	SPADNS - APHA 389
Arsenic	Arsine generation WQO 9
Cyanide	WQO 49
Boron	Curcumin - WQO 13
Trace Elements (Metals):	
Barium	WQO 97
Cadmium	WQO 101 (1)
Chromium	WQO 105 (1)
Copper	WQO 108 (1)
Iron	WQO 110 (1)
Lead	WQO 112 (1)
Lithium	APHA 13th Ed.
Manganese	WQO 116 (1)
Mercury	WQO 118 (1)
Molybdenum	WQO 139
Nickel	WQO 141 (1)
Selenium	Fluorimetric (DAN) (Turner Bulletin)
Vanadium	WQO 153 (1)
Zinc	WQO 155 (1)
Aluminum	WQO 92 (1)

[a] WQO (139) - Refers to the EPA Water Quality Office document, Methods for Chemical Analysis of Water and Wastes (75). Page number is in parentheses.

[b] APHA (126) - Refers to the APHA document, Standard Methods for the Examination of Water and Wastewater (76). The number following is the section reference.

Preservation Methods (WQO Tables 1 and 2)
(1) HNO_3
(2) Refrigeration

spring, and late summer). Composition, abundance, species diversity, and spatial distribution of macrophytes, periphyton, plankton, macroinvertebrates, and fish will be established. The methods of sampling and statistical analysis are those developed by the EPA, USGS, and other affiliates of applied aquatic biology. An identical sampling schedule will be initiated during the post-operational phase.

Solid Waste Disposal, Revegetation

The areas of land expected to be disrupted will be reclaimed in an appropriate manner (74). The details of reclamation are not available for publication.

Noise

No noise monitoring programs have been described in the Equity Oil Company's BX Oil Shale Project Environmental Research Plan (74).

Radioactivity

No program has been developed for the Equity's BX Oil Shale Project (74).

Surface Subsidence

No programs have been developed for the monitoring of surface subsidence at the Equity's BX Oil Shale Project (74).

OCCIDENTAL OIL SHALE INC., LOGAN WASH PROJECT

Environmental monitoring programs have been conducted at Logan Wash since the early 1970's. Documentation of these programs is contained in References 77-90.

Air Resources

Baseline data gathering of air quality and meteorological parameters was conducted for 34 months, from February 1975 through October 1977. During that time, there were two retorting operations: A retort for Room 3 was started in February 1975 and continued to July 1975; Room 4 was retorted from December 1975 to July 1976.

Air Quality—

The air quality measurements consisted of 24-hr concentrations of sulfur dioxide, suspended particulates, carbon monoxide, nitrogen dioxide, hydrocarbons, methane, and hydrogen sulfide. The measurements were made every sixth day for the first year, and every seventh day for the remainder of the program. The location of the sampling site corresponds to the tower location in Figure C-49. Air quality samples were packaged and sent to the Coors Spectro-Chemical Laboratory in Golden, Colorado, for analysis.

Retort Exhaust Gas—

During retorting operations, the retort off-gas was monitored in the stack for hydrocarbons, carbon monoxide, and hydrogen sulfide,/ as well as for flow rate. The person in charge of retort off-gas studies was Dr. H. S. Skogen of Occidental.

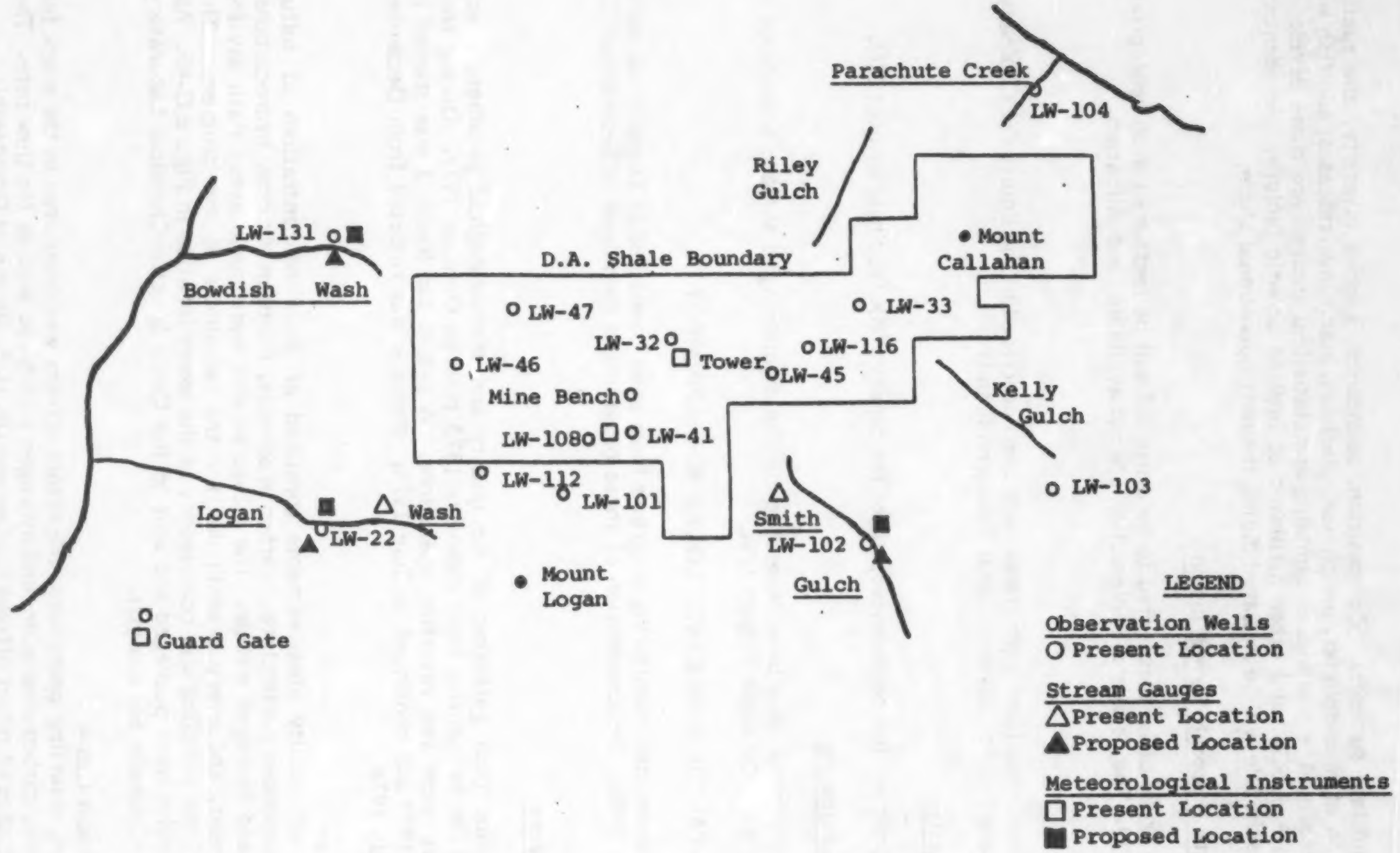

Parachute Creek
LW-104
Riley Gulch
D.A. Shale Boundary
Mount Callahan
LW-131
Bowdish Wash
LW-47
LW-33
LW-32
Tower
LW-116
LW-46
LW-45
Mine Bench
Kelly Gulch
LW-108
LW-41
LW-112
LW-101
LW-103
Logan Wash
LW-22
Smith Gulch
LW-102
Mount Logan
Guard Gate
LEGEND
Observation Wells
○ Present Location
Stream Gauges
△ Present Location
▲ Proposed Location
Meteorological Instruments
☐ Present Location
■ Proposed Location

Figure C-49. Location of meteorological and hydrological installations at Logan Wash.

Meteorology--

Wind speed and direction has been measured, at 30.5 m (100 ft), since 1975 and will continue to be measured. Upper air measurements of temperature and wind speed were made twice a day every six days for a year. The principal investigator for meteorological and ambient air quality studies was Dr. H. E. Craner of H. E. Craner Co.

Water Resources

Surface Water--

Surface-water gaging and sampling stations are situated along the main drainages of the D. A. property at Logan Wash and at Bowdish and Smith Gulches. Future sites are proposed for Roan Creek and Kelly and Riley Gulches. The water quality parameters measured during operation of the Logan Wash Project are presented in Table C-37. A list of the surface-water monitoring stations, the instrumentation utilized at each station, and the sampling frequencies for each are presented in Table C-38.

Groundwater--

Baseline hydrologic and water quality characteristics of the Logan Wash aquifers have been determined by measurement at four deep bedrock wells and at one alluvial well. Water level and quality were determined according to the schedule presented in Table C-38. Seven new alluvial wells (LW-101, 112, 115, 22, 121, 103, and 104), and two deep bedrock wells (LW-106 and 108) are now installed and in operation.

Current mining activities are located at the head of Logan Wash. Since raw shale is being deposited at this point, the most noticeable effect of mining activities on surface waters and groundwater will be evident at the base of Logan Wash. Smith Gulch and Bowdish Wash flank this drainage, and monitoring there will represent background data. Water quality data from Kelly and Riley Gulches, as well as from Parachute Creek, will establish baseline conditions. Roan Creek data will indicate any change in Logan Wash water quality and its effect in the Colorado River drainage system.

Biological Resources

Studies of the biological resources existing in the Logan Wash area were conducted by Claremont Engineering Co. (66, 85-87).

Flora--

Vegetation surveys were conducted at the Logan Wash site once in 1974 by Wirtz (85) and in 1974, 1975, and 1977 by West et al. (86).

In the 1974 survey by Wirtz (85), major species composition was determined by use of line intercept transects at 16 different localities. Using this method, species composition was quantified on the basis of frequency of occurrence and percent cover. Herbaceous species and grasses were classified subjectively on a four-point scale of abundance. The survey was conducted by three people traveling on foot.

The survey of vegetation conducted by West and his associates (86) entailed the positioning of 5- x 100-m (16.4 x 328 ft) macroplots, with their long dimension

TABLE C-37. WATER QUALITY PARAMETERS TO BE MEASURED DURING OPERATION OF THE LOGAN WASH PROJECT[a]

Parameter	Present program	Eliminated
Trace elements:		
Boron	X	X
Lithium	X	X
Beryllium	X	
Sodium	X	
Magnesium	X	X
Aluminum	X	
Silica	X	X
Sulfur	X	
Chloride		
Potassium		
Calcium	X	X
Titanium		
Vanadium	X	
Chromium	X	
Manganese	X	
Iron	X	
Nickel	X	
Copper	X	X
Zinc	X	
Arsenic	X	X
Selenium	X	X
Bromine	X	X
Cyanide	X	X
Lead	X	X
Strontium	X	X
Zirconium	X	X
Barium	X	X
Platinum	X	X
Gold	X	X
Mercury	X	
Radioactive alpha	X	
Radioactive beta	X	
Radium 226		
Major constituents:		
Oil and grease	X	X
TOC		
COD	X	
BOD	X	X
Nitrites	X	
Nitrates	X	X
Ammonia	X	
Sulfates	X	
Carbonate	X	
Bicarbonate	X	
Fluoride	X	
pH	X	
Specific conductance	X	
Total alkalinity	X	
Soluble solids	X	X
Suspended solids	X	
Kjeldahl nitrogen	X	
Phenols	X	

[a] Source: Reference 89.

TABLE C-38. HYDROLOGICAL INSTRUMENTATION AND SAMPLING SCHEDULE OF BASELINE MONITORING PROGRAM AT LOGAN WASH PROJECT AND VICINITY

Current sites	Instrumentation	Sampling frequency[a]
On-Tract:		
Meteorological tower	Precipitation gauge	W
	Evaporation pan	W
Lower mine bench	Precipitation gauge	W
LW-1	Bedrock observation well	---
LW-32a	Bedrock observation well	Q
LW-33	Bedrock observation well	Q
LW-41	Bedrock observation well	---
LW-45	Bedrock observation well	Q
LW-46	Bedrock observation well	Q
LW-47a	Bedrock observation well	Q
Off-Tract:		
Guard Gate - LW-115	Precipitation gauge	W
	Evaporation pan	W
Logan Wash	Stream gauge	M
Smith Gulch - LW-102	Stream gauge	M
	Precipitation gauge	W
Kelly Gulch - LW-103	Alluvial observation well	Q
Riley Gulch - LW-104	Alluvial observation well	Q
	(proposed)	---
	Alluvial observation well	M
	Stream gauge	M
	Precipitation gauge	W
Present Sites:		
LW-103	Alluvial observation well	M
LW-104	Alluvial observation well	M
LW-101	Alluvial observation well	M
LW-112	Alluvial observation well	M
LW-115	Alluvial observation well	M
LW-22	Alluvial observation well	M
LW-121	Alluvial observation well	M
LW-106	Bedrock observation well	Q
LW-108	Bedrock observation well	W

[a] Q = Quarterly
M = Monthly
W = Weekly

upslope. All surveys were accomplished in these areas. The first survey took place in September 1974. Vegetal cover was determined by the line-intercept method, using 100-m (328 ft) tapes along the sides of the macroplots. Density and frequency were determined using 1- x 5-m (3.3 x 16.5 ft) microplots. Frequency was defined simply as the percentage of microplots in which a species occurs within a stand (macroplot).

In the 1975 summer study (86), the size of the woody plant microplot was increased to 50 m^2 (538 ft^2). Ten new microplots were used. Microplots for herbs 1 x 5 m (3.3 x 16.5 ft) were placed randomly within the shrub and tree microplots. Five to ten stands were sampled within each community.

Ground level photos were taken of each macroplot, and field data were transferred to digital punch cards for analysis and comparison. Vegetation was mapped on standard black and white aerial photos.

For the 1977 resurvey, three macroplots were chosen from each community type. The first macroplot had the fewest species and lowest amount of vegetal cover; the second had average composition and cover; and the third illustrated the highest floristic diversity and cover. This resulted in surveys of 23 macroplots. The methods of sampling and analysis were identical to the previous program.

Fauna--

Surveys of local wildlife were conducted by Wirtz (85) in the summer, fall, winter, and spring of 1974 and 1975. All surveys were accomplished on foot. During the summer, three men participated; but only two were responsible for the other three surveys.

Small mammals were censused in representative sites for each habitat. These surveys were accomplished in the summer, utilizing Sherman live traps and Tomahawk wire-mesh traps. Large Tomahawk traps were also set for carnivores during the summer. For the remainder of the year, the surveying of large carnivores was limited to observation of tracks, scat, and kills. All live-trapping data were converted to the number of individuals in each species captured per 100 trap nights in each habitat.

Deer were counted on each survey (morning and night), and age and sex were determined whenever possible. Observations were also made of tracks, pellet groups, beds, trails, brouse, shed antlers, and carcasses or skeletons.

Reptiles were observed irregularly along the survey lines in all seasons except winter. No quantifiable data were obtained. Terrestrial invertebrates were not surveyed.

Birds were observed on all four seasonal surveys. Binoculars and 20-45 power zoom telescopes were used to determine species composition and areas of breeding. The data were converted to the number of individuals per species per man hour of observation.

A map showing the locations of all terrestrial wildlife sampling plots is presented in Figure C-50.

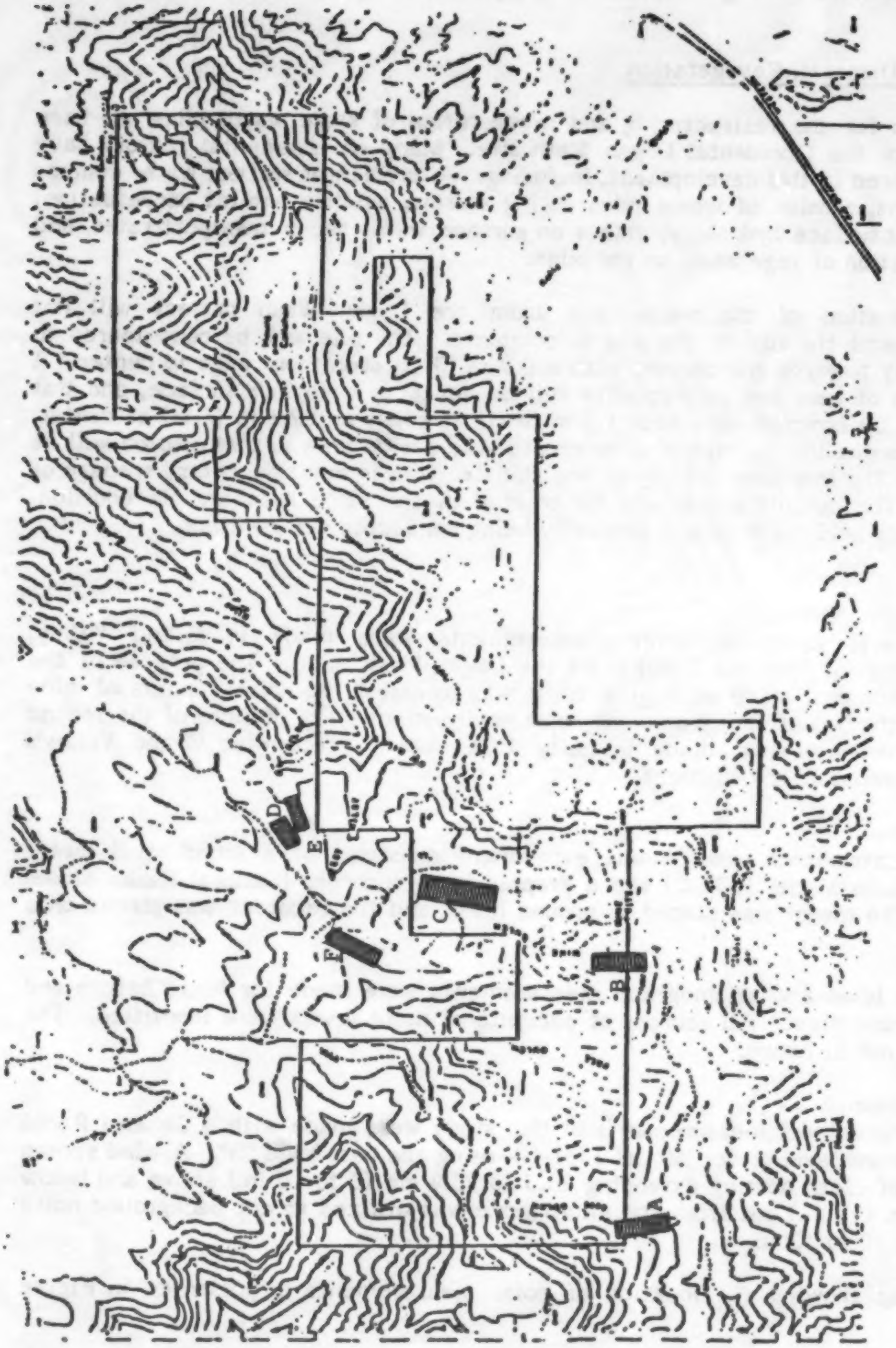


Figure C-50. Location map for biological monitoring program at Logan Wash. (Note location of small mammal study plots, A-F, mine site, and Occidental property boundary. Birds are studied on trapping plots and adjacent areas of the canyon, and deer are censused in the entire canyon where plots are located)

Aquatic Biota--

No data have been generated on the aquatic biological resource of the Logan Wash area.

Solid Waste Disposal, Revegetation

A plan for the restructuring and revegetation of shale waste piles has been developed for the Occidental Logan Wash site. Many environmental factors have been considered in this development, including: Alteration of surface water courses during storms, erosion of waste piles during storms, wildlife habitat perpetuation, effect on subsurface hydrology, effect on surface water debris transport rates, and the perpetuation of vegetation on the piles.

Reclamation of the waste pile from the Logan Wash project will not commence until the life of the pile is complete. The pile will be recontoured to slope slightly towards the center, with a 0.9 m (3-ft) drop from edge to center. A soil addition of very low permeability will be added to the pile's surface, and this will in turn be covered with rock 1.2 m (4 ft) at edges and 2.1 m (7 ft) at center. This design will allow for runoff to be spread over a wide area so that erosion will be minimized. The low permeability of the additive will, in addition, retard seepage of any kind. The outside slopes will be treated in the same manner. In addition, surface water analysis programs presently being conducted will continue.

Noise

Two sets of noise level measurements were made in Grand Valley, approximately 4.1 km (6-1/2 mi) from the Logan Wash mine. The purpose of the first measurement, made in August 1975, was to assess the noise impacts of mine blasting on the Grand Valley ambient noise environment. The purpose of the second group of measurements, made in early 1976, was to determine Grand Valley's preexisting acoustic environment.

August 1975--

The instruments used in this experiment consisted of a sound level meter (General Radio Model 1551-C) and a graphic level recorder (General Radio Model 1521-B). The meter was placed at ground level, and the recorder was placed on a table.

Noise level and seismograph measurements were made for hours before and after the mine blast. All sources of exceptional noise levels were identified. The blast could not be heard.

1976 Measurements--

All sound level measurements in this study were made with a General Radio Company sound level meter (Model 1551-C), using the pass band "B". A wind screen consisting of cloth netting extending 20.3 to 25.4 cm (8 to 10 in.) above and below and 30.5 cm (12 in.) out from the microphone was utilized to cut background noise readings by 10 to 30 dB.

A map showing the location of noise measurements is presented in Figure C-51.

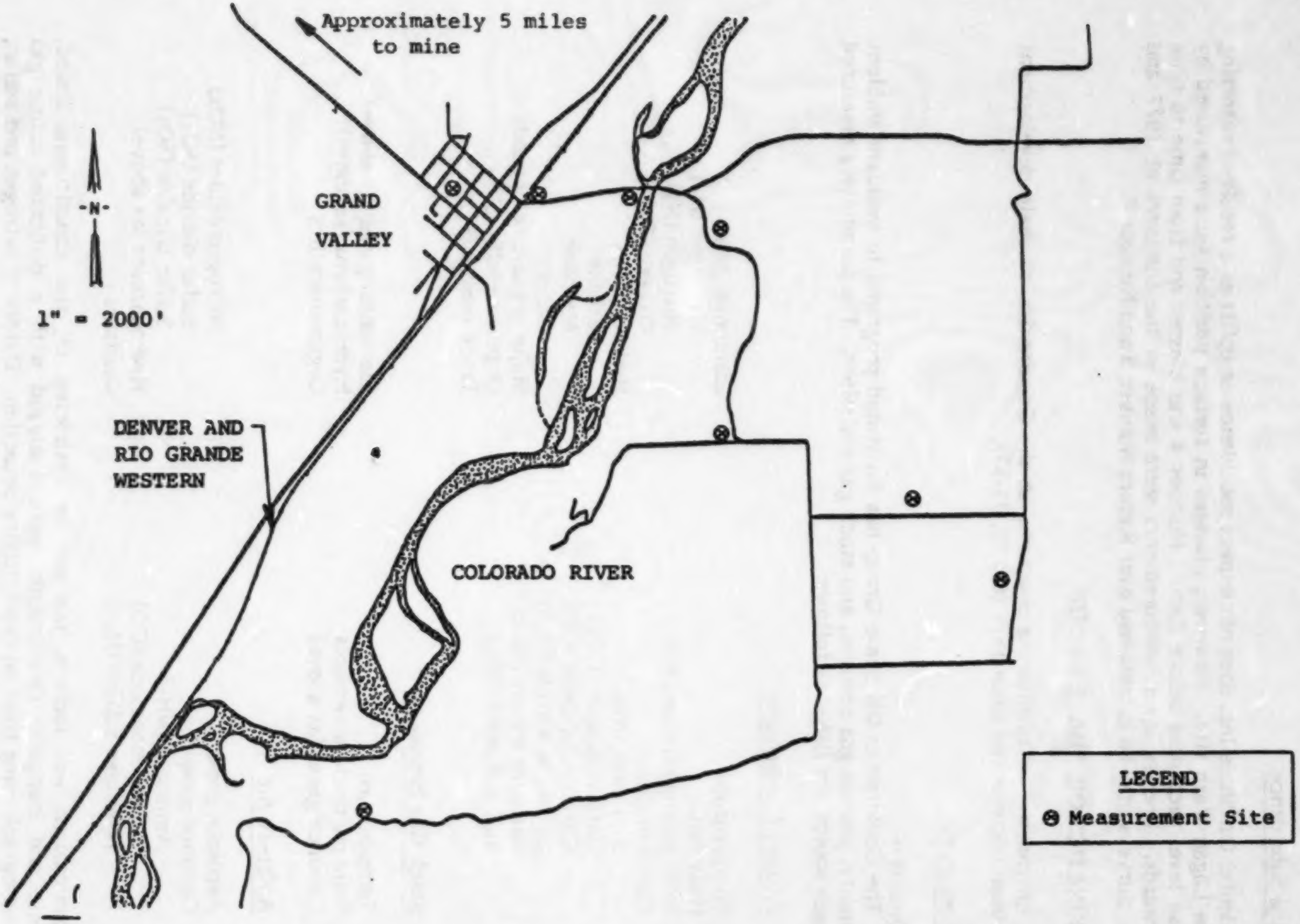

Approximately 5 miles to mine
-N-
1" = 2000'
GRAND VALLEY
DENVER AND RIO GRANDE WESTERN
COLORADO RIVER
LEGEND
⊗ Measurement Site

Figure C-51. Sites of noise measurement at Grand Valley and vicinity.

Surface Subsidence

Occidental Oil Shale Inc. does not expect subsidence or uplift as a result of retorting at the Logan Wash site. However, changes in surface position were monitored by precise level recorders before Retort Number 4 was blasted and from time to time afterwards. Precise level measurements were made in the summers of 1977 and 1978. Surveys may be established over Retort Number 5 and Number 6.

GEOKINETICS OIL SHALE GROUP

Environmental monitoring programs at the Geokinetics oil shale development have been documented since 1977 (69, 72, 94-97).

Air Resources

Air Quality—

The Geokinetics Oil Shale Group has instituted programs to evaluate ambient air quality, process gas streams, and stack gas emissions. The parameters measured for each source are listed as follows:

1. Process Gas Stream

- Temperature
- Heat value
- Solid particulate aerosols
- Common gases
    - Ammonia (NH_3)
    - Carbon dioxide (CO_2)
    - Carbon monoxide (CO)
    - Hydrogen sulfide (H_2S)
    - Nitrogen oxides (NOx)
    - Sulfur dioxide (SO_2)
- Elemental gases
    - Hydrogen (H_2)
    - Nitrogen (N_2)
    - Oxygen (O_2)
- Hydrocarbons
    - Ethane
    - Methane
    - Others
- Major organic compounds
- Organometallics,
- Trace elements

2. Stack Gas Emissions

- Temperature
- Solid particulate aerosols
- Common gases (as above)
- Elemental gases (as above)
- Hydrocarbons (as above)
- Organometallics

3. Ambient Air

- Aerosols, gross
- Common gases
    - Ammonia (NH_3)
    - Carbon monoxide (CO)
    - Hydrogen sulfide (H_2S)
    - Nitrogen oxides (NOx)
    - Sulfur dioxide (SO_2)
    - Sulfur trioxide (SO_3)
- Hydrocarbons (as above)
- Oxidants

Determinations will include, but not be restricted to, the constituents listed. Organic and inorganic constituents were analyzed with a dedicated online gas chromatograph using thermal conductivity detection. Oxides of nitrogen and sulfur, carbon dioxide, elemental gases, organic halides, organometallics, conjugated carbonates, and nitrites were analyzed on an offline gas chromatograph.

In addition, a procedure for photographic monitoring of atmospheric clarity was improved and implemented in June 1978 and was operated through January 1979.

Sampling and analysis of ambient air and monitoring of aerosols by optical and mechanical filtration techniques were established in late 1978.

Meteorology--

Localized meteorological data were gathered from four stations located at various spots around the project site (Figure C-52). A list of the parameters measured and the equipment used at each site is presented in Table C-39. All equipment was calibrated quarterly. Visibility studies were also conducted using seasonal photography.

An additional five meteorological test stations were installed around the test site in 1978 and operated during the retorting period.

Water Resources

Concern exists that precipitated aerosols from the Geokinetics retort process will be carried into the local surface water network (7). For this reason, six surface water sampling stations have been situated to collect samples within 12 hr after a threshold rainfall, or during the year when thawing of snowpack generates measurable runoff. A list of the surface water stations is presented in Table C-40. The water quality parameters measured in the water resources monitoring program are presented in Table C-41. Geokinetics assumes that retort process water will not substantially affect the site surface water quality because the water will be disposed of in evaporation ponds.

As each retort is ignited, wells are drilled proximate to the retort so that water-quality impact determinations can be made. Table C-42 describes the depths of individual wells drilled to date. Water levels are measured on a monthly basis by means of a steel tape or conductivity probe. Water quality samples are taken from active wells at least quarterly. Ten of the 22 wells associated with retorts 11, 12, and 16 are sampled no less often than once each month. All wells associated with a particular retort are sampled on the 10th and 5th days subsequent to retort shutdown and every 10th day for an additional 50 days. All wells in the group are sampled every 2 days during the combustion phase of retort operation. The water quality parameters analyzed are presented in Table C-41.

An additional 13 wells were established by June 1978, and monitoring has commenced since that time. The schedules and parameters are basically the same as for the first round of 32 wells. In 1979, the schedule of water quality parameters to be analyzed has been changed to make the analysis program more cost effective. The changes made in the sampling analyses schedule are listed in Table C-41.

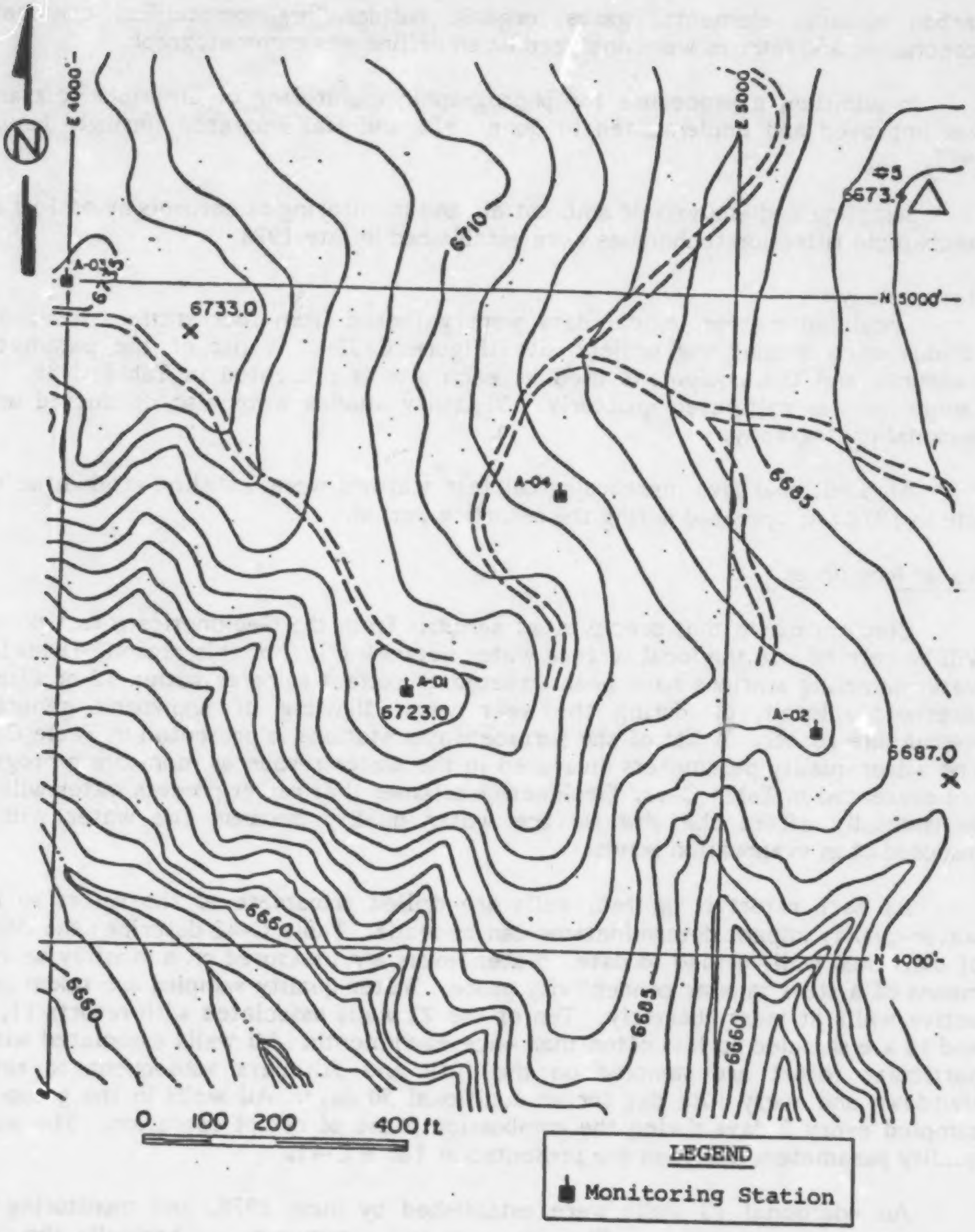

N
E 4000'
E 5000'
N 5000'
N 4000'
A-03
6733.0
6710
#3
6673.4
A-04
6685
A-01
6723.0
A-02
6687.0
6660
6660
6685
6660
0 100 200 400 ft
LEGEND
Monitoring Station

Figure C-52. Locations of meteorological monitoring equipment around Geokinetics project site. [NE¼ NE¼ Sec. 2, T14S, R22E, Utah] (Source: Reference 69.)

TABLE C-39. PARAMETERS AND INSTRUMENTATION USED IN THE METEOROLOGY MONITORING PROGRAM AT GEOKINETICS OIL SHALE PROJECT

Station and parameter	Instrumentation Used		
	Source[a]	Model	Description
A-01:			
Temperature			
Relative humidity			
Wind speed/direction	MRI	1077	Mechanical weather station with #303 rain gage and #370 heater (heated tipping (bucket)
Precipitation			
Barometric pressure	SAI	355BP	Microbarograph
A-02:			
Precipitation	MRI	302	Tipping bucket rain gage
Evaporation	SAI	248(1)	Recording evaporimeter
	BIC	5-349A	Totalizing anemometer
A-03:			
Precipitation	MRI	302	Tipping bucket rain gage
Solar radiation	SAI	653	Pyranograph/actinometer
A-04:			
Air temperatures	SAI	191	Temperature transmitter
	SAI	191D3	Gaged thermistor probe
	EAIC	MS401C-26	Servo chart recorder
Soil temperature	SAI	191	Temperature transmitter
	SAI	191D1	Thermistor probe
	EAIC	MS401C-26	Servo chart recorder
Dew point	SAI	222	Dewpoint probe & transmitter
	SAI	222C	Dewpoint probe weatherhood
	EAIC	MS401C-26	Servo chart recorder
Barometric pressure	SAI	363(5)	Barometric transducer
	SAI	364	Barometric transmitter
	EAIC	MS401C-26	Servo chart recorder
Wind speed	SAI	480-WS-10	Wind speed transmitter
Wind direction	SAI	480-WD-10	Direction transmitter
	SAI	480-100019	Wired crossarm unit
	SAI	480-100086-1	Translator
	EAIC	MS401C-26	Servo chart recorder (spd)
	EAIC	MS401C-26	Servo chart recorder (dir)
Precipitation	SAI	552-1	Transmitting rain gage
	EAIC	MS401C-26	Servo chart recorder
Precipitation rate	BIC	6069A	Rate transmitter gage
	EAIC	MS401C-26	Servo chart recorder
Sunshine duration	SAI	651B	Campbell-Stokes recorder

[a] Manufacturer/supplier abbreviations:

BIC	Belfort Instrument Company
EAIC	Esterline Angus Instrument Corporation
MRI	Meteorology Research, Inc.
SAI	Science Associates, Inc.

TABLE C-40. SURFACE WATER MONITORING STATIONS FOR GEOKINETICS OIL SHALE PROJECT

Station	Subject	Purpose
S-01	(deleted)	
S-02	Evaporation Pond #2	Water level and quality
S-03	Evaporation Pond #3	Water level and quality
S-04	Evaporation Pond #4	Water level and quality
S-0x	(additional stations will be added if necessary)	
S-91	Surface runoff	Water quality
S-92	Surface runoff	Water quality
S-93	Surface runoff	Water quality
S-94	Surface runoff	Water quality
S-95	Surface runoff	Water quality
S-96	Surface runoff	Water quality
S-9x	(additional stations will be added if necessary)	

TABLE C-41. WATER QUALITY PARAMETERS TO BE MEASURED FOR EACH STATION IN WATER RESOURCES MONITORING PROGRAM AT GEOKINETICS OIL SHALE PROJECT

Parameters measured regularly or routinely	Parameters measured quarterly	Parameters no longer measured	Supplemental parameters measured annually
Alkalinity as $CaCO_3$	(In addition to all routine	Germanium	Thiocyanate
Hardness, total	parameters examined)	Uranium	Thiosulfate
pH		Gold	Total sulfur
Specific conductance	Hydroxide as OH	Platinum	Tetrathionate
Temperature	Barium as Ba	Titanium	
Turbidity	Chloride as Cl		
	Copper as Cu		Dissolved solids, volatile
Chemical oxygen demand	Iron as Fe		Suspended solids, volatile
Bromide	Manganese as Mn		
Carbon, total organic	Nickel as Ni		Gross alpha
Dissolved solids, total			Gross beta
Suspended solids, total	Cyanide as Cn		BOD, 5-day
	Phosphate, total, as PO_4-P		Trace elements
Ammonia as NH_3-N	Orthophosphate, as PO_4-P		
Bicarbonate as HCO_3			Total organic carbon
Carbonate as CO_3	Coliform, total		Total solids
Nitrate as NO_3-N	Coliform, fecal		Volatile solids
Nitrate as NO_2-N			Hydroxide
Sulfate as SO_4	Sulfur as S		
Nitrite	Zinc as Zn		
Sulfide			
Calcium as Ca			
Potassium as K	Oil and Grease		
Silica as SIO_2	Phenols		
Sodium as Na	Surfactants		
	Carbon, dissolved organic		
Arsenic as As			
Boron as B			
Fluorine as F			
Magnesium as Mg			
Mercury as Hg			
Molybdenum as Mo			
Selenium as Se			
Antimony			
Beryllium			
Bismuth			
Tin			
Cadmium			
Cobalt			
Vanadium			
Lithium			
Lead			
Silver			
Strontium			

TABLE C-42. GROUNDWATER MONITORING WELLS FOR GEOKINETICS OIL SHALE PROJECT

Well	Depth	Retort	Rationale
W-11	81.5	11	Communication below retorting zone.
W-21	24.0		21-22: Longitudinal and lateral communication within retorting zone.
W-22	24.0		
W-12	90.0	11, 12	Communication below retorting zone.
W-23	54.0	12, 16	Longitudinal and lateral communication within retorting zone.
W-24	53.0		
W-15	100.0	12, 16	Longitudinal and lateral communication within retorting zone.
W-16	93.5		
W-17	93.0		
W-18	95.0		
W-13	100.0	12, 16	Communication below retorting zone.
W-27A	52.5	12	Longitudinal and lateral communication within retorting zone.
W-27B	40.0		
W-28A	52.5		
W-28B	38.0		
W-25	35.0	12	25: Longitudinal and lateral communication.
W-25A	35.5		25A-25B: Lateral communication and dispersion of fracture system.
W-25B	36.0		
W-26	34.0	12	26: Longitudinal and lateral communication.
W-26A	32.0		26A-26B: Lateral communication and dispersion of fracture system.
W-26B	32.5		
W-14[a]	300.0	16	Communication below retorting zone.
W-31	100.0	15	Communication below retorting zone.
W-41	50.0		41-42: Longitudinal and lateral communication within retorting zone.
W-42	50.0		
W-32[a]	140.0	15	Communication below retorting zone.
W-43	57.0		43-44: Longitudinal and lateral communication within retorting zone.
W-44	57.0		
W-51	99.0	13	51: Control, below retorting zone.
W-52	105.0		52-53: Longitudinal communication and dispersion below retorting zone.
W-53	106.0		
W-61	36.0	14	61: Control, within retorting zone.
W-62	45.0		62: Communication within retorting zone.

[a] Coreholes

Biological Resources

Flora—

Eight vegetation sites have been established according to the plot design in Figure C-53. Herbaceous vegetation was sampled in 20 1-m^2 (10.8 ft^2) quadrants permanently located in each sampling site. Shrub layer vegetation was sampled along 20 line-strips permanently situated in each sampling site. Shrub canopy cover, density, and frequency were estimated along each transect. Trees in forested areas were sampled using a point-centered quarter method. Tree density, cover (basal area), and frequency for each species were measured at 48 sampling points. All of this sampling was accomplished in May 1978.

Herbaceous productivity was estimated using the double-sampling technique. In each of the tree stands, 100 0.25-m^2 (2.54 ft^2) quadrants were located along 10 transects. Ten randomly selected quadrants were sampled, the samples were weighed, and the site productivity was estimated using a regression analysis. This study was done between August and September 1978.

Vegetation mapping was produced from aerial photography of the site.

Fauna—

The faunal studies should have been completed by June 1978, however, no publications on the program are currently available.

DOW CHEMICAL COMPANY

The summary analysis of environmental programs at the Dow development in Michigan is based on information gathered from References 73 and 98.

Air Resources

Baseline air quality and meteorology has been determined by information gathered from surrounding county air quality monitoring stations and local weather stations. A specific plan has been developed to monitor ambient air before, during, and after combustion tests.

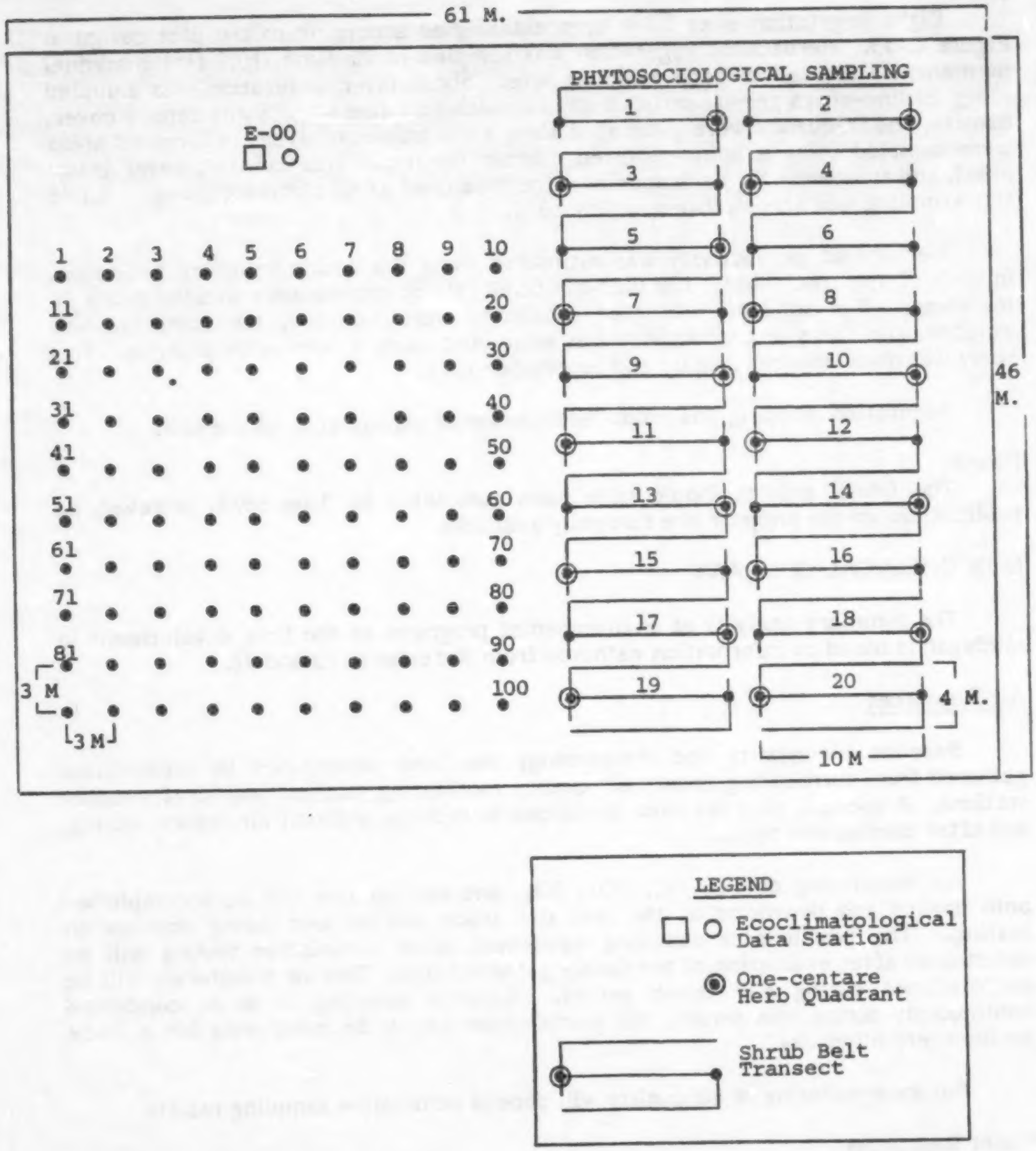
Air monitoring of CO, HC, NOx, SO_2, and particulates will be accomplished both upwind and downwind of the test site stack, before and during combustion testing. The positions of sampling equipment after combustion testing will be determined after evaluation of previously gathered data. This air monitoring will be accomplished during a 7-month period. Gaseous sampling is to be conducted continuously during this period, and particulates are to be monitored for a 24-hr period every other day.

Future monitoring of air quality will depend on baseline sampling results.

Water Resources

Surface Water—

Surface water quality is presently measured at 12 stations on the Dow property (Figure C-54). The water quality parameters being analyzed are listed in Table C-43.


61 M.
PHYTOSOCIOLOGICAL SAMPLING
E-00
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
1
2
3
4
5
6
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8
9
10
11
20
21
30
31
40
41
50
51
60
61
70
71
80
81
90
100
3 M
3 M
46 M.
4 M.
10 M
LEGEND
Ecoclimatological Data Station
One-centare Herb Quadrant
Shrub Belt Transect

Figure C-53. Vegetation plot design for Geokinetics plant monitoring program.

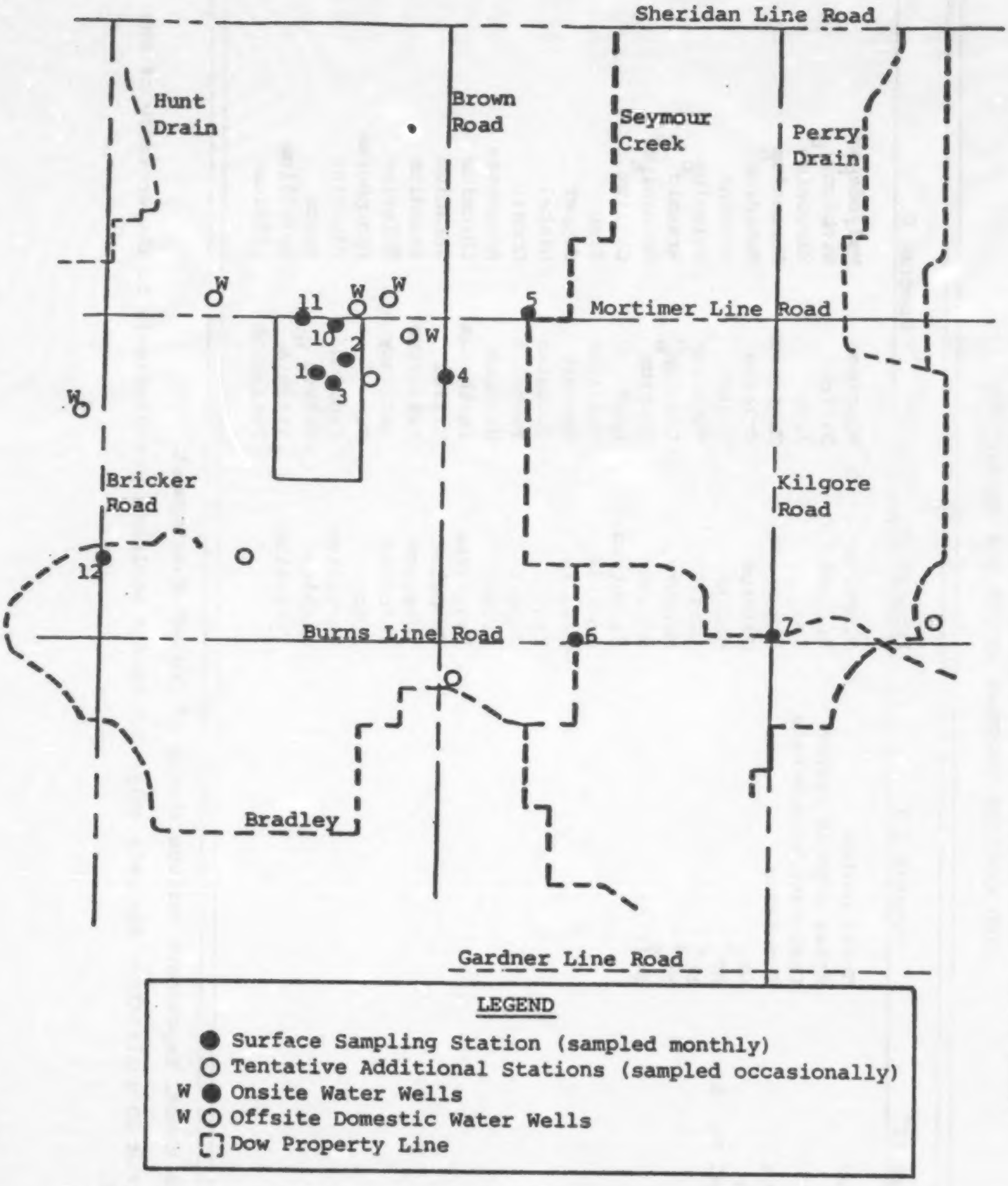
Sheridan Line Road
Hunt Drain
Brown Road
Seymour Creek
Perry Drain
Mortimer Line Road
Bricker Road
Kilgore Road
Burns Line Road
Bradley
Gardner Line Road
W
1
2
3
4
5
6
7
10
11
12
LEGEND
● Surface Sampling Station (sampled monthly)
○ Tentative Additional Stations (sampled occasionally)
W ● Onsite Water Wells
W ○ Offsite Domestic Water Wells
[ ] Dow Property Line

Figure C-54. Surface and groundwater monitoring sites at the Dow development.

TABLE C-43. CONSTITUENTS TO BE DETERMINED IN SELECTED WATER SAMPLE AND ANALYSIS PROGRAMS AT THE DOW DEVELOPMENT

Program II[a]	Program III	Program IV	Program V	
Potassium	Total carbon	Aluminum	Aluminum	Molybdenum
Sodium	Total organic carbon	Silicon	Silicon	Niobium[b]
Calcium	Carbonate/Bicarbonate	Iron	Iron	Zirconium[b]
Magnesium	Phenolics	Magnesium	Magnesium	Strontium
Chloride	NH_3	Calcium	Calcium	Rubidium[b]
Suspended Solids	NO_2	Sodium	Sodium	Bromine
pH	NO_3	Lead	Titanium[b]	Selenium
	SO_4	Mercury	Uranium[b]	Arsenic[b]
	Sulfide	Barium	Thorium[b]	Germanium[b]
		Strontium	Lead	Gallium[b]
		Bromide	Thallium	Zinc
		Arsenic	Mercury	Copper
		Zinc	Tungsten	Nickel
		Copper	Tantalum	Cobalt
		Nickel	Hafnium	Manganese
		Manganese	Lanthanum	Chromium
		Chromium	Barium	Vanadium
		Vanadium	Tellurium	Scandium
		Chloride	Antimony	Chlorine
		Boron	Tin	Phosphorus
		Beryllium	Cadmium	Fluorine
		Lithium	Silver	Boron
		Potassium	Yttruim[b]	Beryllium
			Potassium	Lithium

---

[a] Program number represents various stages of project development.

[b] Subjected to qualitative analysis only; others are analyzed quantitatively to the accuracy of the method.

Groundwater--

Groundwater quality is also being monitored at five offsite domestic wells around the Dow property (Figure C-54). This sampling is carried out on a quarterly basis. Analysis of the parameters listed in Table C-43 is also performed quarterly. Monitoring of groundwater hydrology will not be performed.

Biological Resources

A survey of vegetation was conducted along east-west and north-south transects across the study site. In addition to observation of vegetative cover, the fauna, drainage patterns, and topography were noted. Aerial and ground photography assisted in calculating ground cover and producing a reliable vegetation map.

All baseline studies were performed before the first fracturing or combustion operations. The program will be repeated on a twice-yearly basis.

Noise

The Dow Chemical Co. has taken noise measurements during fracturing and any other time that excessive noise was created by project activities. The equipment used during these measurement activities was submitted to the Environmental Research Institute of Michigan at the time of data submittal. These measurements will be taken again 2 and 4 years after initiation of the fracturing and combustion tests.

Surface Subsidence

During the first year of fracturing and combustion experiments, the area around the subject wells will be intensively monitored. Survey measurements for subsidence determinations will be made with a laser theodolite furnished by Dow. Measurements will be made before each fracturing, immediately afterward, 1 month afterward, and a few times up to a year afterward.

Since frost heave in Michigan can be severe, a set of 43 monuments was established in a radial array around the wells (Figure C-55). The method of constructing these permanent monuments follows:

a. Bore a 9 cm (3.5 in.) diameter hole to a depth of 2 m (6.6 ft) into the soil.

b. Insert a 9 cm (3.5 in.) O.D. PVC pipe into this hole and anchor it at the bottom by driving it in several centimeters, leaving 0.5 m (1.64 ft) above ground.

c. Drive an iron second pipe 2.54 cm (1 in.) O.D. inside the other to a depth of 3 m (3.28 ft), leaving 0.5 m (1.64 ft) above ground.

d. Loosely pack the column between the inside and outside with styrofoam or other temperature-stable medium and seal the cover to exclude moisture.

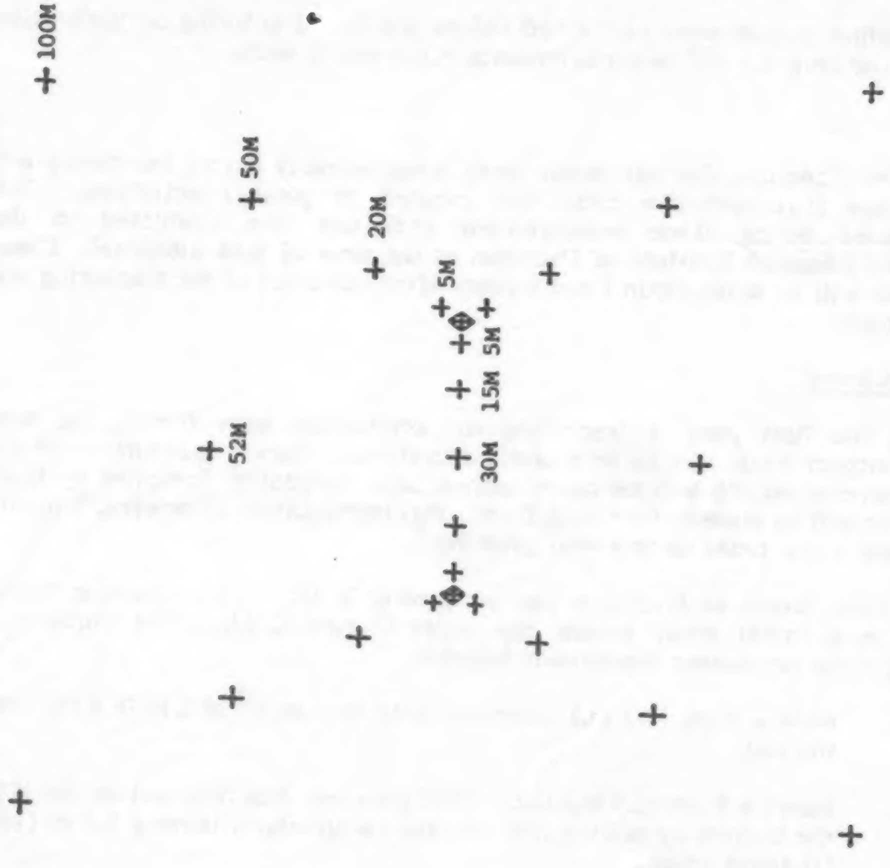
100M
50M
20M
5M
5M
15M
30M
52M

Figure C- 55. Tentative subsidence monument pattern at the Dow development.

TALLEY-FRAC/ROCK SPRINGS PROJECT

The Talley-Frac project has presently been terminated. The sources of information for this report description are References 99-105.

Air Resources

Air Quality--

Baseline air quality and meteorology were determined by air quality monitoring networks existing in the area. The State of Wyoming operates and maintains a network of six air quality sampling stations in the vicinity of the Talley-Frac/Rock Springs site. All of these stations had high-volume samplers for particulates and were used for monitoring SO_2. In addition to the monitoring stations run by the State, various private developments in the area also participated in a monitoring program. An identification of the monitoring sites, parameters measured, and the companies responsible for monitoring in the vicinity of the Talley-Frac project are summarized in Table C-44. In addition to ambient air quality, gas streams from retorting operations were to be monitored. The parameters to be measured were particulates, sulfur dioxide, oxides of nitrogen, carbon monoxide, total hydrocarbons, nonmethane hydrocarbons, hydrogen sulfide, ammonia, total sulfur, heavy metals, carbon dioxide, oxygen, water, nitrogen and hydrogen.

Meteorology--

Baseline meteorology was also determined using the techniques summarized in Table C-45.

Water Resources

Baseline Data Gathering Programs--

Hydrology--The baseline hydrogeological characteristics of the Talley-Frac/Rock Springs site have been determined by the study of geologic structure and lithology, downhole television logging, and pump tests at six observation wells.

Six wells were developed for pump testing. Three (01, 02, and 03) were deep wells drilled to a depth of 172.2 m (565 ft). Three (04, 05, and 06) were shallow wells drilled to a depth of 118.8 m (390 ft). Drawdown rates were measured at each of these wells using submersible pumps 94.6 lpm (25 gpm rate) and electric water level indicators. The locations of these wells are presented in Figure C-56.

Water quality--Prefracture groundwater samples were taken from each of the six observation wells and were analyzed according to two different sampling schedules, A and B. An A analysis was performed on April 13, 1978. Two sets of B analyses were performed on all six wells on April 11 and 13, 1978. Both sampling schedules are illustrated in Tables C-46 and C-47. The wells were sampled using a simple bailing device.

Surface water samples have been taken at six sites along Bitter Creek and the Green River near the site. The responsible agencies include the USGS, EPA, and Western Wyoming Community College (WWC).

TABLE C-44. TALLEY-FRAC/ROCK SPRINGS AMBIENT AIR QUALITY AND METEOROLOGY MONITORING SITES AND PARAMETERS MEASURED

Company	Number of monitoring sites	Parameter measured	Details
	5	Total suspended particulates	
	1	SO_2	Continuous
	1	Meteorology	Wind speed, wind direction
Allied Chemical	4	Total suspended particulates	
	1	Meteorology	Wind speed, wind direction
Texas Gulf Sulfur	4	Total suspended particulates	
	1	Meteorology	Wind speed, wind direction
	1	Meteorology	Surface (6.1 m): Wind speed Wind direction Temperature Humidity Solar radiation Upper (30.5 m): Wind speed Wind direction Temperature Upper (61 m): Wind speed Wind direction Wind components (U.V.W.) Temperature Temperature Differential (6.1 - 61 m):
	1	NO_x	Periodic
	3	SO_2	Continuous
		Total suspended particulates	Continuous, high-volume
		Coefficient of haze	Periodic
	24-30	SO_2	Sulfation plates
		Total settleable particulates	Dustfall buckets

TABLE C-45. ENVIRONMENTAL MONITORING TECHNIQUES USED DURING OPERATION OF THE TALLEY-FRAC OIL SHALE DEVELOPMENT

Description	Methodology
1. Water quality analysis	Emission spectroscopy and wet chemical analysis.
2. Ambient particulate levels	High-volume sampling.
3. Meteorological equipment	Mechanical weather station will collect data on temperature and precipitation. A 10 m (33 ft) tower will be employed to measure surface wind speed and direction and collect solar radiation and relative humidity data. Pibals will be taken seasonally to provide data on upper level winds. Pan evaporation rates will be measured onsite, and an analysis of onsite snow water content will be provided.
4. Air quality monitoring	
a. NOx	Chemiluminescence.
b. SO_2	Pulsed fluorescence.

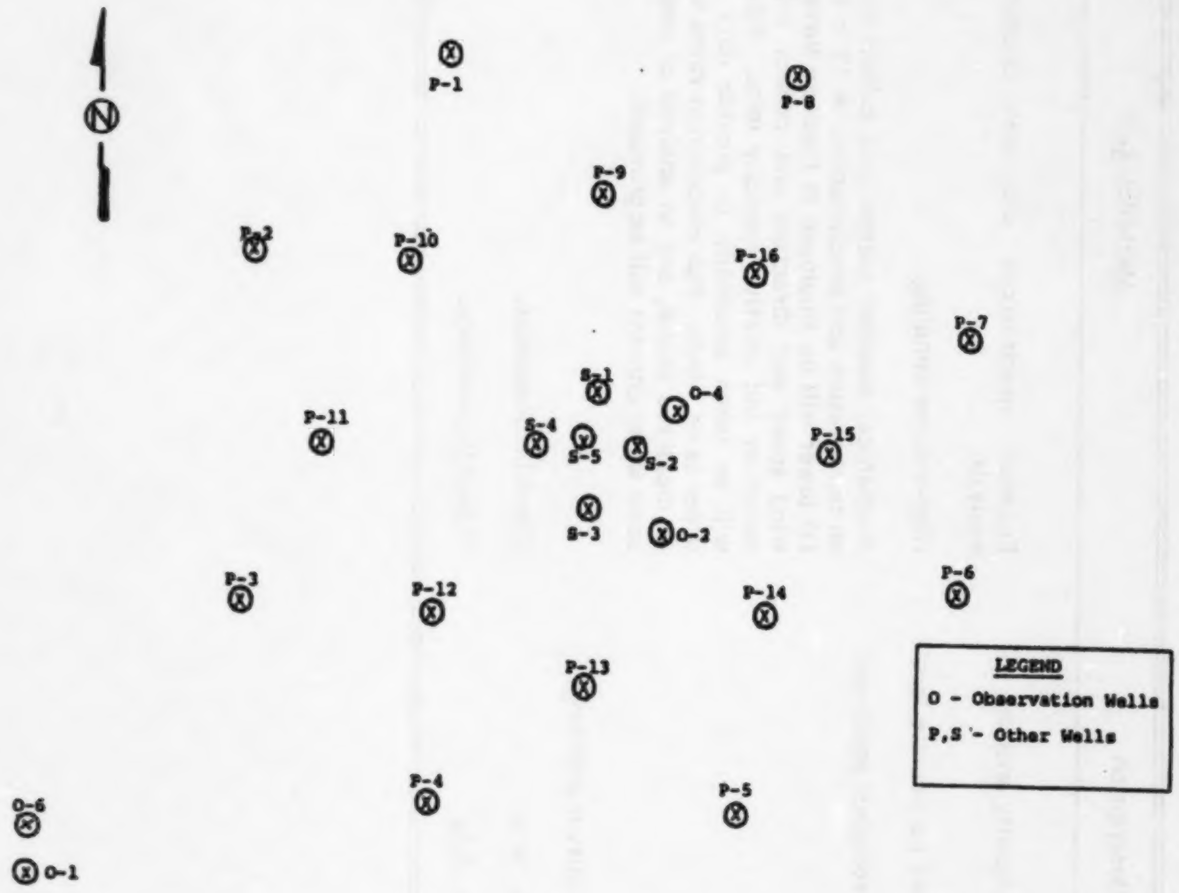
N
P-1
P-8
P-9
P-2
P-10
P-16
P-7
S-1
O-4
P-11
S-4
S-5
S-2
P-15
S-3
O-2
P-3
P-12
P-14
P-6
P-13
P-4
P-5
O-6
O-1
LEGEND
O - Observation Wells
P,S - Other Wells

Figure C-56. Pattern of observation wells at the Talley-Frac development.

TABLE C-46. ANALYTICAL METHODS FOR SCHEDULE A WATER ANALYSIS AT THE TALLEY-FRAC DEVELOPMENT[a]

Parameter	Method	Accuracy (mg/l)
Ammonia	Gas sensing electrode	0.1
Antimony	Flame atomic absorption	0.05
Arsenic	Arsine generation, colorimetric	0.05
Barium	Flame atomic absorption	0.05
Bicarbonate	Alkalinity titration	5.
Bismuth	Flame atomic absorption	0.5
Boron	Curcumin colorimetric	0.05
Bromide	Chloramine-T, colorimetric	2.
Cadmium	Flame atomic absorption	0.002
Calcium	Flame atomic absorption	0.05
Carbonate	Alkalinity titration	5.
Total organic Carbon	Oxidation, IR detection	1.
Cesium	Flame atomic absorption	0.1
Chloride	Mercuric nitrate titration	1.
Chromium	Flame atomic absorption	0.01
Cobalt	Flame atomic absorption	0.01
Conductivity	Conductivity cell	2 µhos
Copper	Flame atomic absorption	0.01
Fluoride	Specific ion electrode	0.1
Iodine	Leuco crystal violet colorimetric	0.1
Iron	Flame atomic absorption	0.01
Lead	Flame atomic absorption	0.01
Magnesium	Flame atomic absorption	0.05
Manganese	Flame atomic absorption	0.005
Mercury	Cold vapor atomic absorption	0.00002
Molybdenum	Flameless atomic absorption	0.005
Nickel	Flame atomic absorption	0.01
Nitrate	Colorimetric, Cd reduction	0.01
pH	Electrode	0.01 units
Phosphorus	Digestion-oxidation, colorimetric	0.1
Potassium	Flame emission	0.1
Silver	Flame atomic absorption	0.01
Sodium	Flame emission	0.1
Dissolved solids	Filtering evaporation, 180°C	1.
Strontium	Flame emission	0.01
Sulfate (as $SO_4^{=}$)	$BaSO_4$ precipitate	10
Tin	Flame atomic absorption	0.5
Zinc	Flame atomic absorption	0.005

---

[a] Source: Reference 75.

TABLE C-47. ANALYTICAL METHODS FOR SCHEDULE B WATER ANALYSIS[a]

Parameter	Method	Accuracy (mg/1)
Alkalinity, total	Standard acid titration	0.1
Ammonia	Electrode-instrumental	0.01
Bicarbonate	Standard acid titration	10.
Calcium	Atomic absorption-instrumental	0.1
Carbonate	Standard acid titration	0.1
Chloride	Mercuric nitrate titration	0.1
Conductivity	Conductivity bridge, instrumental	1 µmhos
Fluoride	Specific ion electrode, instrumental	0.01
Hardness	EDTA titration	0.1
Magnesium	Atomic absorption, instrumental	0.1
Nitrate	Cadmium reduction, colorimetric	0.01
pH	Hydrogen ion electrode, instrumental	0.01
Phosphate	Persulfate digestion, colorimetric	0.01
Potassium	Atomic absorption, instrumental	0.1
Sodium	Atomic absorption, instrumental	0.1
Sulfate	Barium precipitation, gravimetric	0.1
COS	Evaporation and drying, 180°C	10.

[a] Source: Reference 75.

A presentation of the surface water sampling sites and a description of their locations are provided in the following listing:

1. Bitter Creek below Little Bitter Creek; USGS #09216880; Latitude 41°31'0", Longitude 109°18'15".
2. Bitter Creek near Green River, Wyoming; USGS #09216950; Latitude 41°31'25", Longitude 109°25'41".
3. Bitter Creek at Green River Confluence; EPA; Latitude 41°30'59", Longitude 109°25'9".
4. Bitter Creek at Green River Confluence; WWC #562; Latitude 41°31'0", Longitude 109°25'0".
5. Green River near Green River, Wyoming; USGS #09217000; Latitude 41°31'59", Longitude 109°26'54".
6. Green River below Green River, Wyoming; USGS #09217010; Latitude 41°29'46", Longitude 109°26'17"

Post-Hydraulic-Fracture Data Gathering Programs--

At the conclusion of hydraulic fracturing at the Rock Springs site, static water levels and water quality were sampled and analyzed (analysis schedule B) at all six observation wells. The measurements were conducted on May 25, June 22, and July 28, 1978.

Water quality analyses (analysis schedule B) were also run at three Bitter Creek surface water sampling stations.

Post Rubblization Data Gathering Programs--

At the conclusion of fracturing, static water level and water quality analyses (analysis schedule B) were conducted at the previously described six observation wells.

Biological Resources

The study of baseline biological resources in the Talley-Frac/Rock Springs project area was performed by evaluating information already gathered by the Wyoming Water Resources Research Institute and the Wyoming Game and Fish Department, and by conducting random field surveys of the area.

Solid Waste Disposal, Revegetation

All areas disrupted by earth moving, digging, well digging, etc. were reclaimed at the termination of project development. All raw and processed shale stockpiled during project development were to be revegetated and terraced in the manner most acceptable from an environmental and practical standpoint. However, since no shale was stockpiled, this procedure did not occur. The access road and other facilities will be covered over and revegetated with a perennial grass to permit the eventual influx of woody species to their native habitat.

Noise

The Talley-Frac site was categorized as a rural undeveloped locale, and typical EPA noise levels were assigned to the area. Onsite background noise levels were also monitored; however, no details of the monitoring program are published in the reviewed documents.

REFERENCES

1. Rio Blanco Oil Shale Project Final Environmental Baseline Report for Tract C-a and Vicinity, Vols. 1 and 2. Gulf Oil Corp. and Standard Oil (Indiana), Denver, Colorado, 1977.

2. Rio Blanco Oil Shale Project Environmental Baseline Data Accumulation Program for Tract C-a. Gulf Oil Corp. and Standard Oil (Indiana), Denver, Colorado, 1975.

3. Rio Blanco Oil Shale Project Semiannual Report 1977: Interim Studies. Gulf Oil Corp. and Standard Oil (Indiana), Denver, Colorado, March, 1977.

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APPENDIX D

APPLICABLE FEDERAL, STATE, AND LOCAL LEGISLATION, STANDARDS, AND REGULATIONS

LEGISLATION

Federal and State (Colorado, Utah, and Wyoming) pollution control is identified below for the media of air, water, solid waste, noise, radiation, and general.

Air

Federal - The Clean Air Act Amendments of 1977 (PL 95-95)
Colorado - Air Pollution Control Act of 1970, S.B. 69, 1970
Utah - Air Conservation Act, Title 26, Chapter 24
Wyoming - Environmental Quality Act, Articles 1-11

Water

Federal - The Clean Water Act Amendments of 1977 (PL 95-217)
- The Safe Drinking Water Act of 1974 (PL 93-523)
Colorado - Water Quality Control Act, CRS 1973, Title 25, Article 8
Utah - Water Pollution Control Act, Title 73, Chapter 14
Wyoming - Protection of Public Water Supply Act

Solid Waste

Federal - The Resource Conservation and Recovery Act of 1976 (PL 94-580)
Colorado - Solid Waste Disposal Sites and Facilities Act, CRS 1963, Chapter 36, Article 23 (now CRS 1973 30-20-101 through 30-20-115)
Utah - None
Wyoming - Solid Waste Law, Statutes 35-462 through 35-466

Noise

Federal - The Noise Control Act of 1972 (PL 92-574)
Colorado - Noise Abatement Law, CRS 1963, Chapter 66, Article 35 (now CRS 1973, Title 25, Article 12)
Utah - None
Wyoming - None

Radiation

Federal - Clean Air Act (Section 122)
- Resource Conservation and Recovery Act (Section 3001)
Colorado - None
Utah - Radiation Protection Act, Title 26, Chapter 25
Wyoming - Radioactive Isotopes Law, Chapter 35, Article 3

General

Federal - The Toxic Substances Control Act of 1976 (PL 94-469)
- The National Environmental Policy Act of 1969 (PL 91-190)
Colorado - Colorado Mined Land Reclamation Act
Utah - Utah Mined Land Reclamation Act
Wyoming - Wyoming Mined Land Reclamation Act

STANDARDS

Legislation provides for the establishment of national and State ambient standards. Table D-1 presents the NAAQS; Table D-2 presents the state ambient air quality standards for Wyoming (Utah has adopted the NAAQS); and Table D-3 presents a special form of ambient standard, i.e., the PSD increments. These are maximum allowable concentrations (predicted via computer modelling) superimposed upon "baseline" concentrations. The PSD legislation/regulations provided for special areas including National Parks and Wilderness Areas to be designated as Class I. Table D-4 lists the Class I areas in Colorado, Utah, and Wyoming. Figure D-1 shows those Class I areas near oil shale country.

Colorado Ambient Air Quality Standards,* $\mu g/m^3$**

1.	Suspended particulate matter	"Oil Shale Country"
	Annual	45
	24 hour	150

2. Sulfur dioxide concentration-incremental over an established baseline concentration. Colorado I, II, and III SO_2 increments correspond with the same value as the PSD Class I, II, and III values.

Category I areas include all existing National Parks, all existing National Monuments greater than 5,000 acres, all existing National Forest Service Wilderness or Primitive areas of at least 5,000 acres, and Gunnison Gorge Recreation Area. Category II areas include the remainder of the State and Category III areas include the "Front Range" of Colorado.

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* Colorado Code of Regulations - Regulation No. 3
** Reference conditions = ambient conditions

TABLE D-1. NATIONAL AMBIENT AIR QUALITY STANDARDS, UG/M^3***

Pollutant	Averaging time	Primary standard	Secondary standard
SO_2	Annual	80	---
	24 hour	365	---
	3 hour	---	1,300
Particulate matter	Annual	75	60
	24 hour	260	150
NO_x (as NO_2)	Annual	100	100
O_3	1 hour	240	240
CO	8 hour	10,000	10,000
	1 hour	40,000	40,000
Lead	Quarterly	1.5	1.5
HC (non CH_4)	3 hour	160***	160***

* 40 CFR Part 50

** Reference conditions = 760 mm Hg and 25°C

*** Not a standard; a guide to show achievement of the O_3 standard

TABLE D-2. AMBIENT AIR QUALITY STANDARDS-WYOMING

	Standard						
	Annual	Month	24-hour	8-hour	3-hour	1-hour	1/2-hour
Particulate, ug/m^3	60 G.M.	---	150**	---	---	---	---
, COH/1,000 ft	0.4	---	---	---	---	---	---
SO_2, ug/m^3	60	---	260**	---	1,300**	---	---
, sulfation mg $SO_3/100\ cm^2/day$	0.25	0.50	---	---	---	---	---
CO, mg/m^3	---	---	---	10**	---	40**	---
NO_x, ug/m^3	100 A.M.	---	---	---	---	---	---
HC, ug/m^3	---	---	---	---	160**	---	---
Oxidants, ug/m^3	---	---	---	---	---	160**	---
HF, total, ppb	---	---	1	---	---	---	---
forage-ppmw	25	---	---	---	---	---	---
gaseous-ug/cm^2	---	0.3	---	---	---	---	---
H_2S, ug/m^3	---	---	---	---	---	---	*40 twice/5 days *70 twice/5 days

* Not to be exceeded more than

** Not to be exceeded more than once per year

G.M. Geometric Mean

A.M. Arithmetic Mean

TABLE D-3. PREVENTION OF SIGNIFICANT DETERIORATION OF AIR QUALITY (PSD) STANDARDS*

Pollutant	Averaging time	Maximum Allowable Increase, mg/m^3		
		Class I	Class II	Class III
Particulate matter	Annual	5	19	37
	24 hour	10	37	75
SO_2	Annual	2	20	40
	24 hour	5	91	182
	3 hour	25	512	700

* 40 CFR 52.21 and 42 USC 7401 et seq section 163.

Notes:

1. Variances to the Class I increments are allowed under certain conditions as specified at Section 165(d)(c)(ii) and (iii) and at 165(d)(D)(i) of the Clean Air Act of 1977.

2. EPA was to have promulgated similar increments for HC, CO, O_3 and NO_x by August 7, 1979; they are under development. Increments for Pb are due to be promulgated by October 5, 1980.

TABLE D-4. DESIGNATED CLASS I AREAS OF COLORADO, UTAH AND WYOMING

Location	Size (Acres)
Colorado	
Mesa Verde NP	51,488
Rocky Mountain NP	263,138
Black Canyon of the Gunnison WA	11,180
Eagles Nest WA	133,910
Flat Tops WA	235,230
Great Sand Dunes WA	33,450
La Garita WA	48,486
Maroon Bells-Snowmass WA	71,060
Mt. Zirkel WA	72,472
Rawah WA	26,674
Weminuche WA	400,907
West Elk WA	61,412
Additional areas designated by the state	
Florissant Fossil Beds (NM)	
Great Sand Dunes (NM)	
Colorado (NM)	
Dinosaur (NM)	
Black Canyon of the Gunnison (NM)	
Uncompahgre (PA)	
Wilson Mountain (PA)	
Gunnison Gorge	
Utah	
Arches NP	65,098
Bryce Canyon NP	35,832
Canyonlands NP	337,570
Capitol Reef NP	221,896
Zion NP	142,462
Wyoming	
Grand Teton NP	305,504
Yellowstone NP	2,020,625
Bridger WA	392,160
Fitzpatrick WA	191,103
North Absaroka	351,104
Teton WA	557,311
Washakie WA	686,584

NP = National Park
WA = Wilderness Area
NMP = National Memorial Park
NPS = National Park Service
FS = Forest Service
FWS = Fish and Wildlife Service
PA = Primitive Area

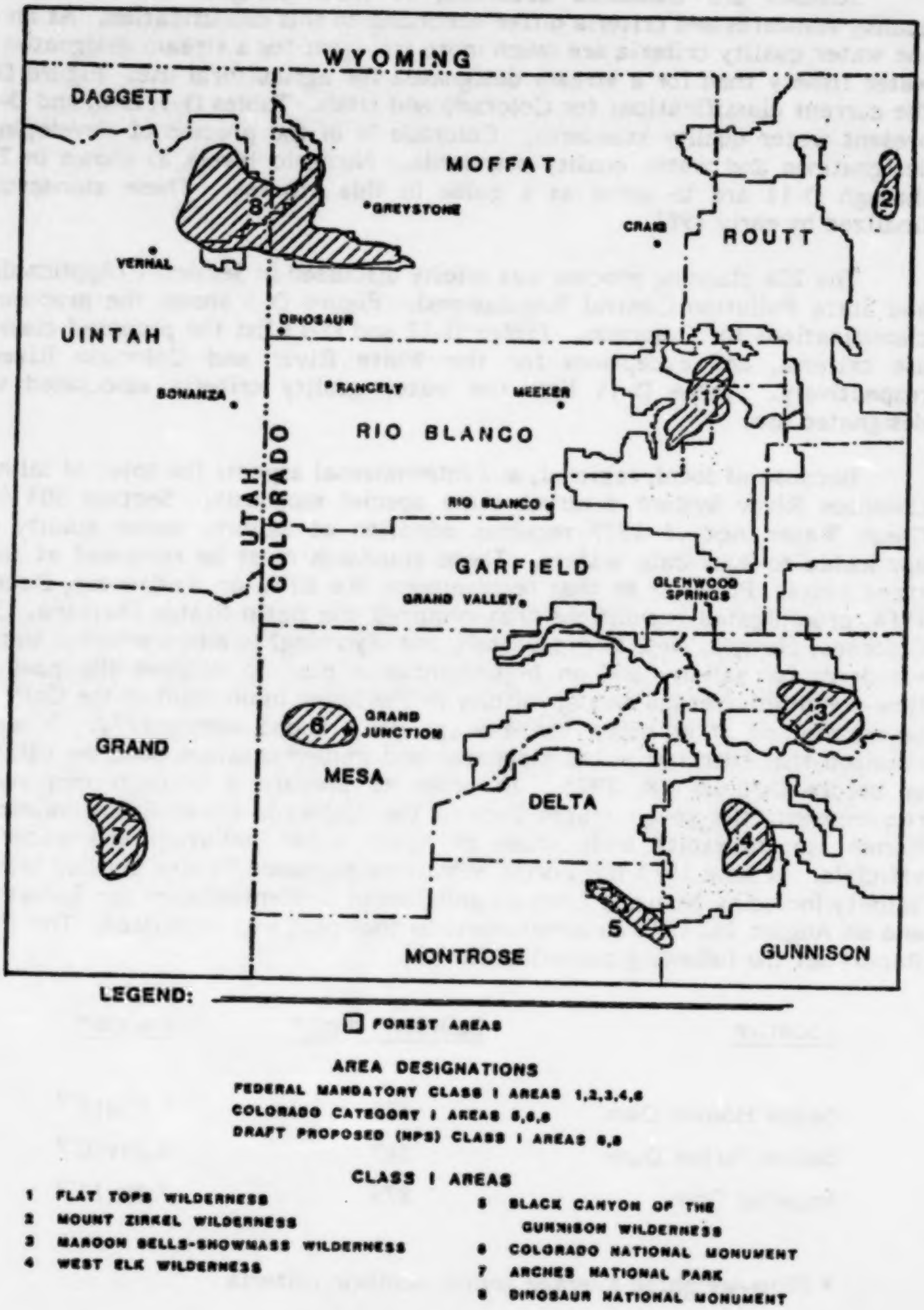
WYOMING
DAGGETT
MOFFAT
8
GREYSTONE
2
VERNAL
CRAIG
ROUTT
DINOSAUR
UINTAH
1
BONANZA
RANGELY
MEEKER
UTAH
COLORADO
RIO BLANCO
RIO BLANCO
GARFIELD
GLENWOOD SPRINGS
GRAND VALLEY
3
6
GRAND JUNCTION
GRAND
MESA
DELTA
7
4
5
MONTROSE
GUNNISON
LEGEND:
☐ FOREST AREAS
AREA DESIGNATIONS
FEDERAL MANDATORY CLASS I AREAS 1,2,3,4,5
COLORADO CATEGORY I AREAS 5,6,8
DRAFT PROPOSED (NPS) CLASS I AREAS 6,8
CLASS I AREAS
1 FLAT TOPS WILDERNESS
2 MOUNT ZIRKEL WILDERNESS
3 MAROON BELLS-SNOWMASS WILDERNESS
4 WEST ELK WILDERNESS
5 BLACK CANYON OF THE GUNNISON WILDERNESS
6 COLORADO NATIONAL MONUMENT
7 ARCHES NATIONAL PARK
8 DINOSAUR NATIONAL MONUMENT

Figure D - 1. Designated Class I areas in oil shale region.

Streams are classified according to their designated/desired use. Water quality standards and criteria differ according to this classification. As an example, the water quality criteria are much more stringent for a stream designated as a cold water fishery than for a stream designated for agricultural use. Figure D-2 shows the current classifications for Colorado and Utah. Tables D-5, D-6, and D-7 list the present water quality standards. Colorado is in the process of developing stream designations and water quality standards. Numeric levels as shown in Table D-8 through D-11 are to serve as a guide in this process. These standards will be finalized by early 1981.

The 208 planning process was briefly discussed in Section 1 (Applicable Federal and State Pollution Control Regulations). Figure D-3 shows the proposed stream classifications for Colorado. Tables D-12 and D-13 list the proposed classification, use criteria, and exceptions for the White River and Colorado River Basins, respectively. Table D-14 lists the water quality criteria associated with each designated use.

Because of local, regional, and international aspects the topic of salinity in the Colorado River System deserves some special emphasis. Section 303 (c) of the Clean Water Act of 1977 requires adoption of salinity water quality standards applicable to interstate waters. These standards must be reviewed at least every three years. Pursuant to that requirement, the EPA, on Wednesday, December 18, 1974, promulgated regulations that required the Basin States (Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming) to adopt ambient water quality standards for salinity and an implementation plan to achieve the goal that...the flow-weighted average annual salinity in the lower main stem of the Colorado River be maintained at or below the average value found during 1972. It was further required that such numerical standards and implementation plans be established on or before October 18, 1975. In order to prepare a uniform response to this requirement, the seven states formed the Colorado River Basin Salinity Control Forum, an interstate body made of State water pollution and water resource officials. In June 1975 the Forum submitted proposed "Water Quality Standards for Salinity Including Numeric Criteria and Plan of Implementation for Salinity Control" and on August 26, 1975 an amendment to that plan was submitted. The 1975 Forum Report set the following numerical limits:

Location	Salinity - mg/l*	lbs/gal*
Below Hoover Dam	723	6.03×10^{-3}
Below Parker Dam	747	6.23×10^{-3}
Imperial Dam	879	7.34×10^{-3}

* Flow-weighted average annual numeric criteria

The implementation plan sets forth basic policies and procedures to achieve the specified standards in addition to specifying specific Federal and non-Federal control measures. Components of the implementation plan of interest to oil shale development are "a no-salt return policy whenever practical" for industrial

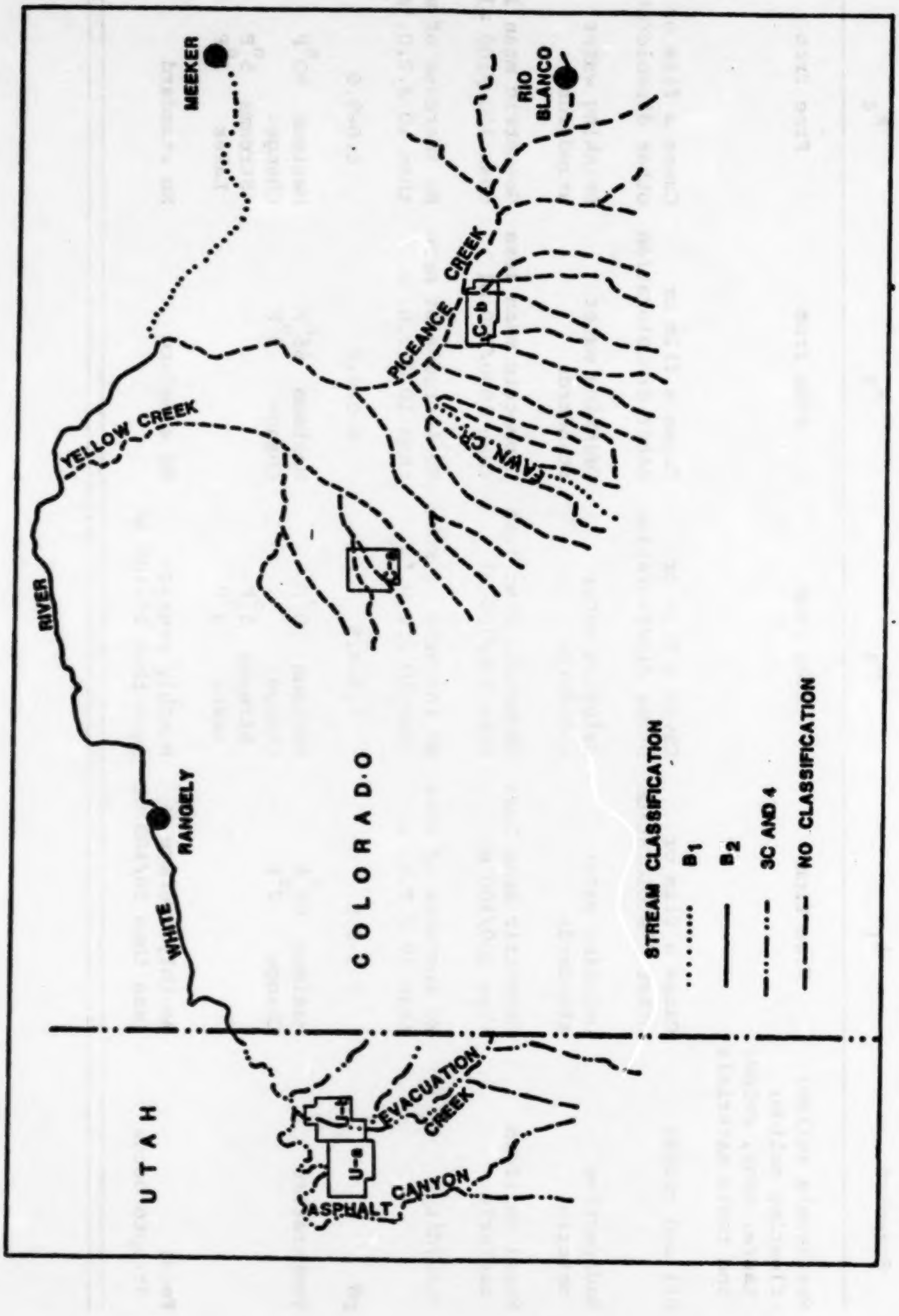
UTAH
COLORADO
WHITE RIVER
RANGELY
YELLOW CREEK
PICEANCE CREEK
MEEKER
RIO BLANCO
FAWN CR.
C-b
C-a
U-a
U-b
EVACUATION CREEK
ASPHALT CANYON
STREAM CLASSIFICATION
B1
B2
3C AND 4
NO CLASSIFICATION

Figure D-2. Current stream classification for oil shale country.

TABLE D-5. SUMMARY OF COLORADO WATER QUALITY STANDARDS

Standard	A_1	A_2	A_3	A_4
Settleable solids; floating solids; taste, odor, color; and toxic materials	Free from	Free from	Free from	Free from
Oil and grease	Cause a film or other discoloration	Cause a film or other discoloration	Cause a film or other discoloration	Cause a film or other discoloration
Radioactive material	Drinking water standards	Drinking water standards	Drinking water standards	Drinking water standards
Fecal coliform bacteria	Geometric mean less than 200/100 ml	Geometric mean less than 200/100 ml	Geometric mean less than 1000/100 ml	Geometric mean less than 1000/100 ml
Turbidity	No increase of more than 10 J.T.U.'s	No increase of more than 10 J.T.U.'s	No increase of more than 10 J.T.U.'s	No increase of more than 10 J.T.U.'s
pH	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0
Temperature	Maximum 68°F Change 2°F	Maximum 90°F Change: Streams 5°F Lakes 3°F	Maximum 68°F Change 2°F	Maximum 90°F Change: Streams 5°F Lakes 3°F
Fecal streptococcus	Monthly average less than 20/100 ml	Monthly average less than 20/100 ml	No standard	No standard

TABLE D-6. NUMERICAL STANDARDS FOR PROTECTION OF BENEFICIAL USES OF WATER

	Classes											
	Domestic Source			Recreation & Aesthetics		Aquatic Wildlife				Agri-culture	Indus-try	Special
Constituent	1A	1B	1C	2A	2B	3A	3B	3C	3D	4	5	6
Bacteriological (No./100 ml)												
(30-day geometric mean)												
Maximum total coliforms	1	50	3,000	1,000	5,000	a	a	b	a	a	c	c
Maximum fecal coliforms	a	a	2,000	200	2,000	a	a	b	a	a	c	c
Physical												
Total dissolved gases	a	a	a	a	a	d	d	b	a	a	c	c
Minimum DO (mg/l)[e]	a	a	5.5	5.5	5.5	6.0	5.0	b	5.5	a	c	c
Maximum temperature	a	a	a	a	a	20°C	27°C	b	a	a	c	c
Maximum temp. change	a	a	a	a	a	2°C	4°C	b	a	a	c	c
pH	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	b	6.5-9.0	6.5-9.0	c	c
Turbidity increase[f]	a	a	a	10 NTU	10 NTU	10 NTU	10 NTU	b	15 NTU	a	c	c
Chemical (Maximum mg/l)												
Arsenic, dissolved	.05	.05	.05	a	a	a	a	b	a	.1	c	c
Barium, dissolved	1	1	1	a	a	a	a	b	a	a	c	c
Cadmium, dissolved	.010	.010	.010	a	a	.0004[g]	.004[g]	b	a	.01	c	c
Chromium, dissolved	.05	.05	.05	a	a	.10	.10	b	.10	.10	c	c
Copper, dissolved	a	a	a	a	a	.01	.01	b	a	.2	c	c
Cyanide	a	a	a	a	a	.005	.005	b	a	a	c	c
Iron, dissolved	a	a	a	a	a	1.0	1.0	b	1.0	a	c	c
Lead, dissolved	.05	.05	.05	a	a	.05	.05	b	a	.1	c	c
Mercury, total	.002	.002	.002	a	a	.00005	.00005	b	.00005	a	c	c
Phenol	a	a	a	a	a	.01	.01	b	a	a	c	c
Selenium, dissolved	.01	.01	.01	a	a	.05	.05	b	a	.05	c	c
Silver, dissolved	.05	.05	.05	a	a	.01	.01	b	a	a	c	c
Zinc, dissolved	a	a	a	a	a	.05	.05	b	a	a	c	c
NH_3 as N (un-ionized)	a	a	a	a	a	.02	.02	b	a	a	c	c
Chlorine	a	a	a	a	a	.002	.002	b	a	a	c	c
Fluoride, dissolved[h]	1.4-2.4	1.4-2.4	1.4-2.4	a	a	a	a	b	a	a	c	c
NO_3 as N	10	10	10									
Boron, dissolved	a	a	a	a	a	a	a	b	a	.75	c	c
H_2S	a	a	a	a	a	.002	.01	b	a	a	c	c
TDS[i]	a	a	a	a	a	a	a	b	a	1200	c	c

---

[a] Insufficient evidence to warrant the establishment of numerical standard. Limits assigned on case-by-case basis.

[b] Standards will be determined on a case-by-case basis (See Appendix D).

[c] Standards will be determined on case-by-case basis.

[d] Not to exceed 110% of saturation.

[e] These limits are not applicable to lower water levels of impoundment.

[f] For Classes 2A, 2B, 3A, and 3B at background levels of 100 NTUs or greater, a 10% increase limit will be used instead of the numeric values listed. For Class 3D at background levels of 150 NTUs or greater, a 10% increase limit will be used instead of the numeric value listed. Short term variances may be considered on a case-by-case basis.

[g] Limit shall be increased threefold if $CaCO_3$ hardness in water exceeds 150 mg/l.

[h] Maximum concentration varies according to the daily maximum mean air temperature.

Temp. °C	mg/l
12.0 and below	2.4
12.1 to 14.6	2.2
14.7 to 17.6	2.0
17.7 to 21.4	1.8
21.5 to 26.2	1.6
26.3 to 32.5	1.4

[i] Total dissolved solids (TDS) limit may be adjusted on a case-by-case basis.

(continued)

TABLE D-6. (continued)

Constituent	1A	Domestic Source 1B	1C	Recreation & Aesthetics 2A	2B	3A	3B	3C	3D	4	5	6
Radiological (Maximum pCi/l)												
Gross Alpha	15	15	15	a	a	15(g)	15(g)	b	15(g)	15(g)	c	c
Radium 226, 228 combined	5	5	5	a	a	a	a	b	a	a	c	c
Strontium 90	8	8	2	a	a	a	a	b	a	a	c	c
Tritium	20,000	20,000	20,000	a	a	a	a	b	a	a	c	c
Pesticides (Maximum ug/l)												
Endrin	.2	.2	.2	a	a	.004	.004	b	.004	a	c	c
Lindane	4	4	4	a	a	.01	.01	b	.01	a	c	c
Methoxychlor	100	100	100	a	a	.03	.03	b	.03	a	c	c
Toxaphene	5	5	5	a	a	.005	.005	b	.005	a	c	c
2, 4-D	100	100	100	a	a	a	a	b	a	a	c	c
2, 4, 5-TP	10	10	10	a	a	a	a	b	a	a	c	c
Pollution indicators[j]												
Gross beta (pCi/l)	50	50	50	a	a	50	50	b	50	50	c	c
BOD (mg/l)	a	a	5	5	5	5	5	b	5	5	c	c
NO_3 as N (mg/l)				4	4	4	4	b	a	a	c	c
PO_4 as P (mg/l)[k]	a	a	a	.05	.05	.05	.05	b	a	a	c	c

[a] Insufficient evidence to warrant the establishment of numerical standard. Limits assigned on case-by-case basis.

[b] Standards will be determined on a case-by-case basis (See Appendix D).

[c] Standards will be determined on case-by-case basis.

[j] Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

[k] PO_4 as P (mg/l) limit for lakes and reservoirs shall be .025.

TABLE D-7. NUMERICAL STANDARDS FOR PROTECTION OF CLASS 3C WATER USE

Parameter	Description
Physical	
Minimum D.O. (mg/l)	5[a]
Maximum temperature	27°C[b]
Maximum temperature change	4°C
pH	6.5-9.0
Turbidity increase (NTU)	15[c]
Chemical (Maximum mg/l)	
Cadmium, dissolved - T	0.004
Chromium, dissolved - T	0.1
Copper, dissolved - T	0.01
Cyanide	0.005
Iron, dissolved - T	1.0
Lead, dissolved - T	0.05
Mercury, total	0.0005 vs 0.00005
Phenol	0.01
Selenium, dissolved - T	0.05
Silver, dissolved - T	0.01
Zinc, dissolved - T	0.05
Chlorine	0.2 vs 0.01-0.007
H_2S	0.02 vs 0.002
Radiological (Maximum pCi/l)	
Gross Alpha	15
Gross Beta	30
Pesticides (Maximum mg/l)	
Endrin	0.004
Lindane	0.01
Mexoxychlor	0.03
Toxaphene	0.005
Pollution Indicators[d]	
BOD (mg/l)	5.0
NO_3 as N (mg/l)	4.0

[a] Minimum D.O (mg/l) limitation is 4 in the following segments:
San Rafael River and tributaries, from confluence with Green River to confluence with Ferron Creek
Malad River and tributaries, from confluence with Bear River to state line

[b] Maximum temperature limitation is 35°C in the following segments:
Virgin River and tributaries from state line to headwaters except as listed in Appendix B

[c] At background levels of 150 NTU's or greater, a 10% increase limit will be used instead of the numeric values. Short term variances may be considered on a case-by-case basis.

[d] Investigations should be conducted to develop more information where these pollution indicator levels are exceeded.

TABLE D-8. PHYSICAL AND BIOLOGICAL PARAMETERS

Parameter	Recreational		Aquatic Life			Agriculture	Domestic Water Supply	
	Class 1 Primary Contact	Class 2 Secondary Contact	Class 1 Cold Water Biota	Class 1 Warm Water Biota	Class 2		Class 1	Class 2
Physical:								
D.O. (mg/l)[a]	Aerobic[b](A)	Aerobic[b](A)	6.0[c](G) 7.0-Spawn	5.0(A)	*	Aerobic[b](A)	Aerobic[b](A)	Aerobic[b](A)
pH (Std. Units)	6.5-9.0(B[m])		6.5-9.0(A)	6.5-9.0(A)	*		5.0-9.0(A)	5.0-9.0(A)
Suspended solids (mg/l) & Turbidity	d	d	d --	d	*	d	1.0 TU(E)	d
Temperature (°C)			Max 20°C w/3°C increase(G)[e]	Max 30°C w/3°C increase(G)[e]	*			
Biological:								
Fecal coliforms per 100 ml (Geometric mean)	200(A)[f]	2000(G[m])[f]			*		0[g](E)	2000(E)

[a] Where dissolved oxygen levels less than these levels occur naturally, a discharge shall not cause a further reduction in dissolved oxygen in receiving water.

[b] An effluent shall be regulated to maintain aerobic conditions, and a guideline of 2.0 mg/liter dissolved oxygen in an effluent should be maintained, unless demonstrated otherwise.

[c] A 7 mg/liter standard, during periods of spawning of cold water fish, shall be set on a case-by-case basis as defined in the NPDES permit for those dischargers whose effluent would affect fish spawning.

[d] Suspended solid levels will be controlled by Effluent Limitation Regulations, Basic Standards, and Best Management Practices (BMP's).

[e] Temperature shall maintain a normal pattern of diurnal and seasonal fluctuations with no abrupt changes and shall have no increase in temperature of a magnitude, rate, and duration deemed deleterious to the resident aquatic life. Generally, a maximum 3°C increase over a minimum of a four-hour period, lasting for 12 hours maximum, is deemed acceptable for discharges fluctuating in volume or temperature. Where temperature increases cannot be maintained within this range using BMP, BATEA, and BPWTT control measures, the Division will determine whether the resulting temperature increases preclude an aquatic life classification.

[f] Fecal coliform is an indicator only. It may indicate the presence of pathogenic organisms; however, fecal coliform counts from agriculture or urban runoff may not indicate organisms detrimental to human health.

[g] For drinking water with or without disinfection.

*To be established on a case-by-case basis.

TABLE D-9. INORGANIC PARAMETERS

Parameter	Recreational		Aquatic Life			Agriculture	Domestic Water Supply	
	Class 1 Primary Contact	Class 2 Secondary Contact	Class 1 Cold Water Biota	Class 1 Warm Water Biota	Class 2		Class 1	Class 2
Inorganics:								
Ammonia (mg/l as N)			0.02 unionized(A)	0.06 unionized(G)	*		0.5[a](B)	0.5[a](B)
Chlorine Mg/l) - Total Residual			0.003(H)	0.003(H)	*			
Cyanide - Free (mg/l)			0.005(H)	0.005(H)	*	0.2(G)	0.2(B,D*)	0.2(B,D*)
Fluoride (mg/l)					*		[b](E)	[b](E)
Nitrate (mg/l as NO					*	100[c](B)	10(A,B)	10(A,B)
Nitrite (mg/l as N)			0.05(G)	0.5(G)	*	10[c](B)	1.0[a](B)	1.0[a](B)
Sulfide as H_2S (mg/l)			0.002 Undissociated(A)	0.002 Undissociated	*		0.05(F)	0.05(F)
Boron (mg/l)					*	0.75(A,B)		
Chloride (mg/l					*		250(F)	250(F)
Sulfate (mg/l)					*		250(F)	250(F)

[a] To be applied at the point of water supply intake.

[b] Fluoride levels vary from 2.4 mg/liter at 12.0°C and below, to 1.4 mg/liter between 26.3°C and 32.5°C, based upon the annual average of the maximum daily air temperature (see National Interim Primary Drinking Water Regulations for specific limitations or any modification thereto).

[c] In order to provide a reasonable margin of safety to allow for unusual situations such as extremely high water ingestion or nitrite formation in slurries, the NO_3-N plus NO_2-N content in drinking waters for livestock and poultry should be limited to 100 ppm or less, and the NO_2-N content alone be limited to 10 ppm or less.

*To be established on a case-by-case basis.

TABLE D-10. METAL PARAMETERS

Parameter	Recreational		Aquatic Life							Agriculture	
	Class 1 Primary Contact	Class 2 Secondary Contact	Class 1 Cold Water and Warm Water Biota Water Hardness or Alkalinity (mg/l)[a]					Or Bioassay (Application factor, or other)[b]	Class 2	Class 1	Class 2
Total Metals - Total conc. in mg/l			0 to 100	100 to 200	200 to 300	300 to 400	400 plus				
Aluminum (soluble)			0.1(C)	0.1(C)	0.1(C)	0.1(C)	0.1(C)	Bioassay	*		
Arsenic			0.05(C)	0.05(C)	0.05(C)	0.05(C)	0.05(C)	Bioassay	*	0.1(A)	0.05(E)	0.05(E)
Barium									*		1.0(E)	1.0(E)
Beryllium			0.01(A)	0.3(C)	0.6(C)	0.9(C)	1.1(A)	Bioassay	*	0.1(A,B)		
Cadmium			0.004(A,C,H)	0.001(A,C,H)	0.005(C,H)	0.010(C,H)	0.015(C,H)	Bioassay	*	0.01(B)	0.010(E)	0.010(E)
Chromium-Trivalent			0.1(H)	0.1(H)	0.1(H)	0.1(H)	0.1(H)		*	0.1(B)	0.05(E)	0.05(E)
Chromium-Hexivalent			0.025(H)	0.025(H)	0.025(H)	0.025(H)	0.025(H)		*	0.1(B)	0.05(E)	0.05(E)
Copper			0.005(C)	0.01(C)	0.01(C)	0.02(C)	0.04(C)	0.1AF(A)	*	0.2(B)	1.0(F)	1.0(F)
Iron			1.0(A,C)	1.0(A,C)	1.0(A,C)	1.0(A,C)	1.0(A,C)		*		0.3(sol)(F)	0.3(sol)(F)
Lead			0.004(C,H)	0.025(C,H)	0.050(C,H)	0.100(C,H)	0.150(C,H)	Bioassay[c]	*	0.1(B)	0.05(E)	0.05(E)
Manganese			1.0(C)	1.0(C)	1.0(C)	1.0(C)	1.0(C)	Bioassay	*	0.2(B)	0.05(sol)(F)	0.05(sol)(F)
Mercury			0.00005(A)	0.00005(A)	0.00005(A)	0.00005(A)	0.00005(A)		*		0.002(E)	0.002(E)
Nickel			0.05(C)	0.10(C)	0.20(C)	0.30(C)	0.40(C)	0.01AF(A)	*	0.2(B)		
Selenium			0.05(C,H)	0.05(C,H)	0.05(C,H)	0.05(C,H) -	0.05(C,H)	0.001AF(H)	*	0.02(B,D)	0.01(E)	0.01(E)
Silver			0.00010(C,H)	0.00010(C,H)	0.00015(C,H)	0.00020(C,H)	0.00025(C,H)	0.01AF(A)	*		0.05(E)	0.05(E)
Thallium			0.015(C)	0.015(C)	0.015(C)	0.015(C)	0.015(C)	Bioassay	*			
Uranium			0.03(C)	0.2(C)	0.4(C)	0.8(C)	1.4(C)	Bioassay	*			
Zinc			0.05(C,H)	0.05(C,H)	0.10(C,H)	0.30(C,H)	0.60(C,H)	0.01AF(A)	*	2.0(B)	5.0(F)	5.0(F)

---

[a] Concentrations of total alkalinity or other chelating agents attributable to municipal, industrial or other discharges or agricultural practices should not alter the total alkalinity or other chelating agents of the receiving water by more than 20%. Where the complexing capacity of the receiving water is altered by more than 20% or where chelating agents are released to the receiving water which are not naturally characteristic of that water, specific effluent limitations for pertinent parameters shall be established. In no case shall instream modification or alteration of total alkalinity or other chelating agents be permitted without Commission authorization.

[b] Where required, bioassay procedures may be used to establish standards for a particular situation.

[c] For bioassay, lead concentration is based on soluble lead measurements; i.e., non-filterable lead using a 0.45 micron filter.

*To be established on a case-by-case basis.

TABLE D-11. ORGANIC PARAMETERS

Parameter	Recreational		Aquatic Life		Agriculture	Domestic Water Supply	
	Class 1 Primary Contact	Class 2 Secondary Contact	Class 1 Cold Water and Warm Water Biota	Class 2		Class 1	Class 2
Organic[a] (mg/l):							
Chlorinated Pesticides							
Aldrin[b]			0.000003(A,H,I)[c]	*			
Dieldrin[b]			0.000003(A,H,I)[c]	*			
DDT (DDD & DDE)[b]			0.000001(A,H,I)	*			
Endrin			0.000004(A)	*		0.0002(E)	0.0002(E)
Heptachlor[b]			0.000001(A)	*			
Lindane			0.00001(A,H)	*		0.004(E)	0.004(E)
Methoxychlor			0.00003(A)	*		0.1(E)	0.1(E)
Mirex			0.000001(A,H)	*			
Toxaphene			0.000005(A,H,I)	*		0.005(E)	0.005(E)
Orthophosphate Pesticides							
Demeton			0.0001(A,H)	*			
Endosulfan			0.000003(A)	*			
Guthion			0.00001(A,H)	*			
Malathion			0.0001(A,H)	*			
Parathion			0.00004(A,H)				
Chlorophenoxys (Herbicides)							
2,4-D				*		0.1(E)	0.1(E)
PCB (polychlorinated Biphenyls)[d]			0.000001(A,H,I)	*		d	d
Chlorophenol			0.001(A,H)	*		0.001(A)	0.001(A)
Monohydric phenol			0.5(H)	*		0.001(A)	0.001(A)
Benzidine			0.0001(A,I)	*		0.0001(E)	0.0001(E)

---

[a] All organics not on this partial list are covered under Basic Standards, Section 3.1.11.

[b] The persistence, bioaccumulation potential, and carcinogenicity of these organic compounds cautions human exposure to a minimum (EPA).

[c] Aldrin and dieldrin in combination should not exceed 0.000003 mg/l.

[d] Every reasonable effort should be made to minimize human exposure (EPA).

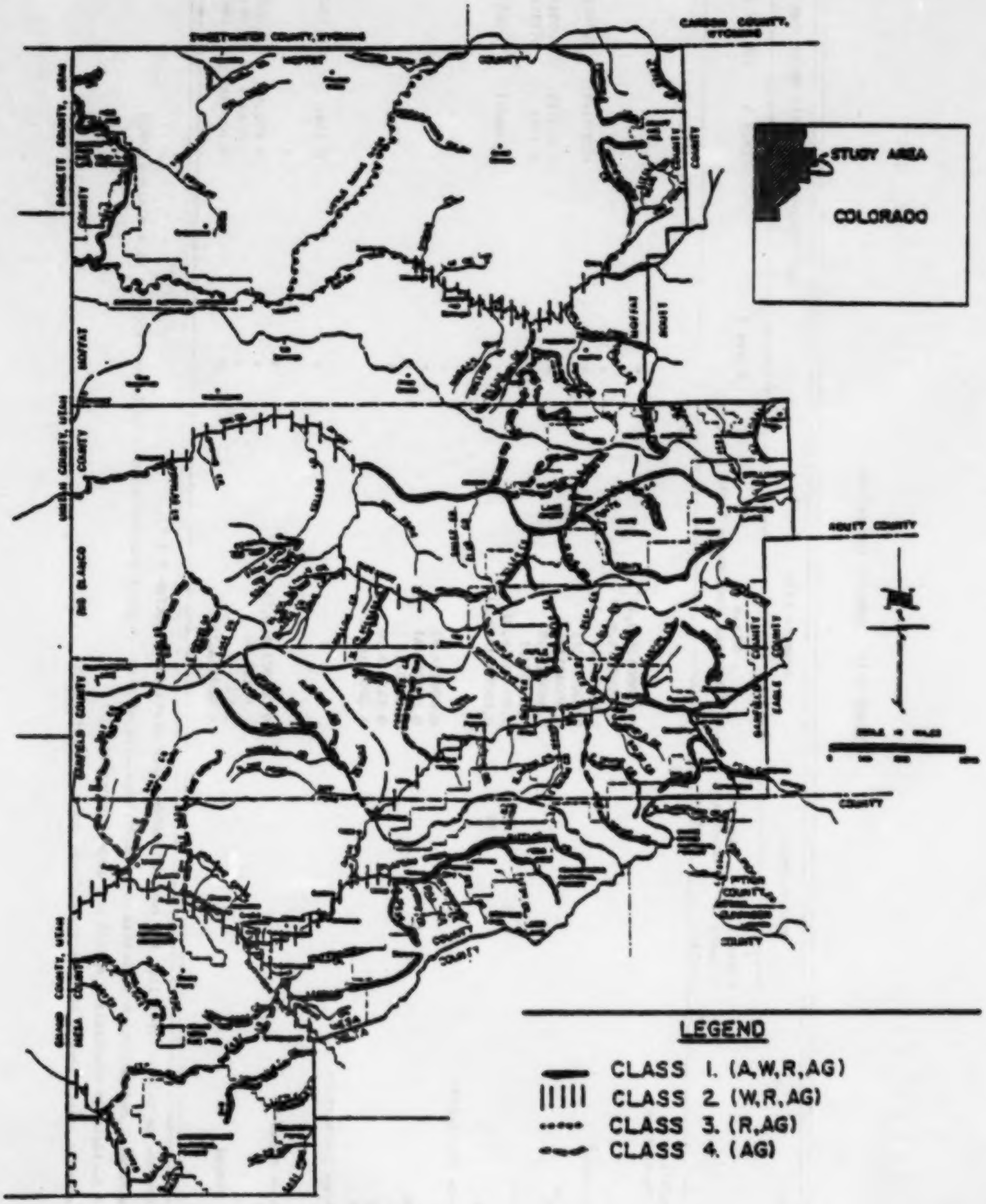
SWEETWATER COUNTY, WYOMING
CARBON COUNTY, WYOMING
STUDY AREA
COLORADO
ROUTT COUNTY
MOFFAT
RIO BLANCO
GARFIELD COUNTY
EAGLE COUNTY
PITKIN COUNTY
MESA COUNTY
LEGEND
CLASS 1. (A,W,R,AG)
CLASS 2. (W,R,AG)
CLASS 3. (R,AG)
CLASS 4. (AG)

Figure D - 3. Proposed stream classifications.

TABLE D-12. PROPOSED STREAM CLASSIFICATIONS AND CRITERIA EXCEPTIONS - WHITE RIVER BASIN

Segment	Proposed classification[a]	Criteria[b]	Limiting parameters[c]																				
			T. Al	T. Cd	T. Cu	T. Fe	T. Pb	T. Mn	D. Mn	T. Hg	T. Mo	T. Se	T. Ag	T. Zn	SO_4	PO_4	P	Alk	FC	pH	TDS	TSS	Temp
White River from Trappers' Lake to Piceance Creek	Class 1	A	●	●	X	X	X			X			•	●		&	X	●		O		●	O
		W		●			X		X								X			O	●		
		R															X		O	O			
		AG	●	●	X	X		•		X									O	O			
White River from Piceance Creek to Douglas Creek	Class 2	W		●			•		•											O	●		
		R															X		O	O			
		AG	●	●	•	X		•		X									O	O			
White River from Douglas	Class 3	AG	●	●	•	●		●		•									O	●			
South Fork White River	Class 1	A	●	●									●	●									
		W																					
		R																		●			
		AG									●												
Miller Creek	Class 1	A		●														●					
		W													X						●		
		R																		●			
		AG																					
Curtis Creek	Class 3	AG																					
Coal Creek	Class 3	AG																					
Little Beaver Creek	Class 3	AG									X												
Piceance Creek between Ryan Gulch and 14 Mile Creek	Class 2	W					●						●							●			
		R															X						
		AG																					
Black Sulfur Gulch	Class 3	AG																					
Stewart Gulch	Class 3	AG																					
W. Fork Stewart Gulch	Class 3	AG																					
Corral Gulch	Class 3	AG																					
Box Elder Creek	Class 3	AG																					
E. and W. Douglas Creek	Class 3	AG																					

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[a] Class 1 - Combination of A, W, R, and AG use criteria good fishing, high quality water.
Class 2 - Combination of W, R, and AG use criteria, domestic water supply.
Class 3 - Agricultural use only.

[b] A - Aquatic Life
W - Water Supply
R - Recreation
AG - Agriculture

[c] T. = Total
D. = Dissolved

● - Permanent Exception
X - Temporary Exception, 10 years
O - Temporary Exception, 5 years
• - No violations in this stream segment, but violations occur in other reaches of stream. More data needed.

TABLE D-13. PROPOSED STREAM CLASSIFICATIONS AND CRITERIA EXCEPTIONS - COLORADO RIVER BASIN

Segment	Proposed classification[a]	Use criteria[b]	Limiting Parameters[c]																					
			T. Cd	T. Fe	T. Pb	T. Mn	D. Mn	T. Hg	T. Mo	T. Se	T. Zn	Cl	Na	SO_4	NH_3	PO_4	P	Alk	BOD	FC	T. Mg	pH	TDS	TSS	Temp
Colorado River from Garfield County line to Canyon Creek	Class 1	A		X				●			O					X	X	●						●	
		W																							
		R															X								
		AG							O																
Colorado River from Canyon Creek to Plateau Creek	Class 2	W																					●		
		R															X			O		●			
		AG							O											O					
Colorado River from Plateau Creek to Utah line	Class 2	W	X		O		X			O				●						O			●		
		R															X			O		●			
		AG	X		O			●	O											O					
Roaring Fork River from Study Area boundary to Colorado River	Class 1	A						●			O							●							
		W																							
		R																				●			
		AG						●																	
Fourmile Creek	Class 1	A																							
		W																							
		R																				●			
		AG																							
Crystal River from Study Area boundary to Roaring Fork River	Class 1	A														X									
		W																							
		R																				●			
		AG																							
Headwaters of E. W. Divide Creek to National Forest boundary	Class 1	A																●						●	
		W																							
		R																							
		AG																							
Divide Creek below National Forest boundary	Class 3	AG																							
Roan Creek above Clear Creek	Class 1	A																●						●	O
		W											*	O									●		
		R																				●			
		AG																							
Roan Creek below Clear Creek	Class 3	AG																							
Brush Creek	Class 1	A																●						●	
		W																					●		
		R																				●			
		AG																							

---

[a] Class 1 - Combination of A, W, R, and AG use criteria, good fishing, high quality water.
Class 2 - Combination of W, R, and AG use criteria, domestic water supply.
Class 3 - Agricultural use only.

[b] A - Aquatic Life
W - Water Supply
R - Recreation
AG - Agriculture

[c] T. = Total
D. = Dissolved

● - Permanent Exception
X - Temporary Exception, 10 years
O - Temporary Exception, 5 years
* - No violations in this stream segment, but violations occur in other reaches of stream. More data needed.

(continued)

TABLE D-13. (continued)

Segment	Proposed classification^a	Use criteria	Limiting Parameters^c																						
			T. Cd	T. Fe	T. Pb	T. Mn	D. Mn	T. Hg	T. Mo	T. Se	T. Zn	Cl	Na	SO_4	NH_3	PO_4	P	Alk	BOD	FC	T. Mg	pH	TDS	TSS	Temp
Clear Creek	Class 3	AG																							
Rifle Creek above Rifle Gap Reservoir	Class 1	A																				*			
		W																				*			
		R																				*			
		AG																				*			
Parachute Creek	Class 3	AG							O																
West Fork of Parachute Creek	Class 1	A																*							
		W					*																		
		R																							
		AG																							
Plateau Creek above Mesa Creek	Class 1	A																*					●		
		W																							
		R																				*			
		AG																							
Plateau Creek below Mesa Creek	Class 2	W																							
		R																				●			
		AG																							
Mesa Creek	Class 1	A		X												*		*							
		W																							
		R																				*			
		AG		X						-															
Big Salt Wash	Class 3	AG																					●		
Salt Creek	Class 3	AG			*																		●		
W. Salt Creek	Class 3	AG																					●		
Gunnison River	Class 2	W	X		X					O				●									●		
		R													/		X			O		O			
		AG	X			X		●																	
Kannah Creek above Grand Mesa National Forest Boundary	Class 1	A																O							
		W												●									●		
		R																							
		AG																							
Kannah Creek below Forest boundary	Class 3	AG																							
Dolores River	Class 2	W										●	●	●	O				O		●		●		
		R															●		O						
		AG				X		●																	

---

[a] Class 1 - Combination of A, W, R, and AG use criteria, good fishing, high quality water.
Class 2 - Combination of W, R, and AG use criteria, domestic water supply.

[b] A - Aquatic Life
W - Water Supply
R - Recreation
AG - Agriculture

[c] T. = Total
D. = Dissolved

● - Permanent Exception
X - Temporary Exception, 10 years,
O - Temporary Exception, 5 years
* - No violations in this stream segment, but violations occur in other reaches of stream. More data needed.

TABLE D-14. RECOMMENDED WATER QUALITY CRITERIA

Parameter	Water uses		
	Water supply	Aquatic life/wildlife	Recreation
Alkalinity as $CaCO_3$	---	30-130 mg/l**	---
Aluminum - Total	---	0.1 mg/l	---
Aluminum - Dissolved	---	0.1 mg/l**	---
Total Ammonia as N	0.5 mg/l**	---	---
Unionized Ammonia as N	---	0.02 mg/l	---
Arsenic - Total	0.01 mg/l	0.05 mg/l	---
Barium - Total	1.0 mg/l	---	---
Beryllium - Total	---	1.1 mg/l	---
Boron	1.0 mg/l**	---	---
Cadmium - Total	0.01 mg/l	0.003 mg/l	
Chloride - Total	250 mg/l	---	
Chromium - Total	0.05 mg/l	0.3 mg/l*	
Fecal Coliform	2000/100 ml*	2000/100 ml**	200/100 ml
Color	75 color units**	---	---
Copper - Total	1.0 mg/l	0.030 mg/l	---
Cyanide	0.20 mg/l	0.005 mg/l	---
Hardness	---	---	---
Iron - Total	---	1.0 mg/l	---
Iron - Dissolved	0.3 mg/l	0.3 mg/l**	---
Lead - Total	0.05 mg/l	0.03 mg/l	---
Manganese - Total	0.05 mg/l	1.0 mg/l	---
Manganese - Dissolved	0.05 mg/l	---	---
Mercury - Total	0.002 mg/l	0.00005 mg/l	---
Molybdenum - Total	---	---	---
Nickel - Total	---	0.1 mg/l	---
Nitrate - N	10 mg/l	---	---
Dissolved Oxygen	4.0 mg/l*	5.0 - 6.0 mg/l Min.	2.0 mg/l Min.
pH	5.0 - 9.0	6.5 - 9.0	6.5 - 9.0
Phenols	0.001 mg/l	0.001 mg/l	---
Total PO_4-P	---	0.025 mg/l - lakes**	---
Phthalate Esters	---	0.003 mg/l	---
PCB	---	0.000001 mg/l	---
Selenium - Total	0.01 mg/l	0.05 mg/l	---
Silver - Total	0.05 mg/l	0.0001 - 0.0025 mg/l[f]	---
Silver - Dissolved	---	0.0001 mg/l	---
Sodium	270 mg/l[d]**	---	---
Sulfate - Total	250 mg/l	---	---
TDS	500 mg/l**	---	---
TSS	---	25 mg/l-median[g]	---
H_2S (undissociated)	0.05 mg/l	0.002 mg/l	---
Temperature	---	h	---
Zinc - Total	5.0 mg/l	0.03 mg/l	---

Unless otherwise indicated the recommended criteria corresponds with Proposed State Standards.

* Differs from Proposed State Standards.

** CWA 208 Recommendation only (no Proposed State Standard).

*** For agricultural uses, the WQCC, except in a few instances, did not distinguish between irrigation and livestock uses. The CWA 208 attempted to distinguish the differences. Therefore, under livestock there are numerous differences between 208 and WQCC numbers. Under irrigation the lower recommended criteria match WQCC numbers.

[a] Continuous irrigation, all soils (match WQCC Proposed State Standards).

[b] Short-term irrigation, neutral to alkaline fine textured soils.

[c] Long-term irrigation on sensitive crops.

[d] Maximum concentration for a moderately restricted sodium diet.

[e]	
Water from which no detrimental effects will usually be noticed.	500 mg/l
Water which can have detrimental effects on sensitive crops.	500 - 1000 mg/l
Water that may have adverse effects on many crops and requires careful management practices.	1000 - 2000 mg/l
Water that can be used for tolerant plants on permeable soils with careful management practices.	2000 - 5000 mg/l

[f] Limiting concentration dependent on hardness.

[g] Value represents maximum increase in ambient concentration due to discharge.

[h] Cold water maximum is 20°C, warm water maximum is 30°C, and both categories limit temperature changes to 3°C.

(continued)

TABLE D-14. (continued)

Parameter	Water uses Irrigation	 Livestock
Alkalinity as $CaCO_3$	---	---
Aluminum - Total	5.0 mg/l[a], 20.0 mg/l[b]**	5.0 mg/l**
Aluminum - Dissolved	---	---
Total Ammonia as N	---	---
Unionized Ammonia as N	---	---
Arsenic - Total	0.1 mg/l	0.2 mg/l***
Barium - Total	---	---
Beryllium - Total	0.1 mg/l[a], 0.5 mg/l[b]***	---
Boron	0.75 mg/l[c]	5.0 mg/l***
Cadmium - Total	0.01[a], 0.05 mg/l[b]*	0.05 mg/l***
Chloride - Total	---	---
Chromium - Total	0.1 mg/l[a], 1.0 mg/l[b]***	0.1 mg/l
Fecal Coliform	1000/100 ml	1000/100 ml
Color	---	---
Copper - Total	0.2 mg/l[a], 5.0 mg/l[b]	0.5 mg/l***
Cyanide	0.2 mg/l	0,2 mg/l
Hardness	---	---
Iron - Total	5 mg/l[a], 20 mg/l[b]**	---
Iron - Dissolved	---	---
Lead - Total	5 mg/l[a], 10 mg/l[b]*	0.1 mg/l
Manganese - Total	0.2 mg/l[a], 10 mg/l[b]***	---
Manganese - Dissolved	---	---
Mercury - Total	---	0.00005 mg/l**
Molybdenum - Total	0.01 mg/l[a], 0.05 mg/l[b]	0.5 mg/l
Nickel - Total	0.1 mg/l*	---
Nitrate - N	100 mg/l	$NO_3 + NO_2$ 100 mg/l
Dissolved Oxygen	2.0 mg/l	2.0 mg/l
pH	4.5 - 9.0**	---
Phenols	---	---
Total PO_4-P	---	---
Phthalate Esters	---	---
PCB	---	---
Selenium - Total	---	0.5 mg/l
Silver - Total	---	---
Silver - Dissolved	---	---
Sodium	---	---
Sulfate - Total	---	---
TDS	[e]	3000 mg/l**
TSS	---	---
H_2S (undissociated)	---	---
Temperature	---	---
Zinc - Total	2.0 mg/l	25 mg/l ***

Unless otherwise indicated, the recommended criteria corresponds with Proposed State Standards.

* Differs from Proposed State Standards.

** CWA 208 Recommendation only (no Proposed State Standard).

*** For agricultural uses, the WQCC, except in a few instances, did not distinguish between irrigation and livestock uses. The CWA 208 attempted to distinguish the differences. Therefore, under livestock there are numerous differences between 208 and WQCC numbers. Under irrigation the lower recommended criteria match WQCC numbers.

[a] Continuous irrigation, all soils (match WQCC Proposed State Standards).

[b] Short-term irrigation, neutral to alkaline fine textured soils.

[c] Long-term irrigation on sensitive crops.

[d] Maximum concentration for a moderately restricted sodium diet.

[e] Water from which no detrimental effects will usually be noticed. 500 mg/l
Water which can have detrimental effects on sensitive crops. 500-1000 mg/l
Water that may have adverse effects on many crops and requires careful management practices. 1000-2000 mg/l
Water that can be used for tolerant plants on permeable soils with careful management practices. 2000-5000 mg/l

[f] Limiting concentration dependant on hardness.

[g] Value represents maximum increase in ambient concentration due to discharge.

[h] Cold water maximum is 20°C, warm water maximum is 30°C, and both categories limit temperature changes 3°C.

discharges, disposal of blow-down water from power plants in a manner to avoid return of salts to the river system, use of saline maine drainage water for compacting spent shale as well as in plant processing operations, and control of drainage water from spent shale deposits. In large part the philosophy is concerned with reducing the dissolved solids content of waters over which one has control due to use in some industrial or agricultural process. A concurrent and major effort in controlling salinity in the Colorado River is reduction in salinity produced by natural sources.

In November of 1976 EPA approved the Forum's adopted water quality standards and implementation plan. Subsequently EDF et al. challenged the approval. The litigation was recently ruled upon in favor of EPA. Pursuant to the provision in Section 303 that the standards be reviewed every 3 years the Forum has proposed certain revisions to the water quality standards and the implementation plan. The Forum adopted the "Policy for Implementation of Colorado River Salinity Standards through the NPDES Permit Program" in February 1977 and developed the "Proposed 1978 Revision, Water Quality Standards for Salinity including Numeric Criteria and Plan of Implementation for Salinity Control" in August 1978. Utah adopted the 1978 revision on July 2, 1979 and Colorado held a hearing in February 1980. However the basic numeric criteria on the lower stem of the Colorado River remains the same. The key components of the 1978 Forum Report include the following:

1. Construction of salinity control units including the Grand Valley, Meeker Dome, Glenwood Springs, and Unita Basin projects in "oil shale country"

2. Implementation of the 208 Water Quality Management Plans

3. Placing of effluent limits on industrial and municipal discharges via the NPDES program

Since the oil shale developers are directly affected by Provision #3, the NPDES provision merits further discussion. The objective for discharges adopted by the Forum and by the State of Colorado is "a no-salt return wherever practicable". This provision is waived for the individual discharger if his salt load reaching the main stem is less than .9 tonne (1 ton) per day or 318 tonnes (350 tons) per year. In cases where a no-salt return is not practicable the discharger must:

1. Describe the project, the proposed salt load, and water supply

2. Describe alternative plans for the elimination of the salt discharge including how the removed salts will be prevented from reentering the surface or groundwater

3. Give costs of the alternatives

Municipal discharges are allowed an incremental 400 mg/l TDS (3.34×10^{-3} lbs/gal) in their discharge over their intake. This provision may be waived under certain circumstances.

In order to provide guidance for future oil shale developers, the source standards listed below were developed from existing NPDES permit limits and from oil shale related facilities. Possible treatment schemes were discussed in Section 4 of this document.

Drinking water standards have been promulgated under the Safe Drinking Water Act. Community water supplied must comply with these values. Also the standards provide criteria for the designation of hazardous and solid wastes via the RCRA hazardous waste criteria. These standards are listed in Tables D-15 and D-16.

PERMIT PROGRAMS - EXISTING

Enabling legislation and environmental standards are attained and maintained through the promulgation and enforcement of emissions/effluent regulations. Section 6 of this document summarizes applicable guidance for the establishment of these emission/effluent regulations.

Air NSPS for oil shale related facilities are listed in Table D-17. Section 6 describes BACT limits in PSD permits which have been issued. Figures D-4 and D-5 and the Colorado limitations shown below provide information on Colorado emissions regulations.

Colorado Emission Limitations

Regulation No. 1*

III. B.6.d. vi and vii.

0.3 pounds of SO_2 (for the sum of all SO_2 emissions from a facility) per barrel of oil provided/processed

*1. Sources producing less than 1000 BPD are exempt

2. Emission limits apply to production and refining of shale oil

Regulation No. 8

No person shall cause emissions of hydrogen sulfide into the ambient air which exceed 142 micrograms per cubic meter (0.10 ppm).

NPDES permits are issued to facilities which have, or have the potential for, a discharge to a navigable surface water course. The history, philosophy, and criteria for these source standards is provided below.

Under the River and Harbor Act of 1886 (recodified in the Rivers and Harbors Act of 1889) effluent limitations were required by some states. The Federal Water Pollution Control Act Amendments (FWPCA) of 1977 changed the thrust of enforcement water quality standards to effluent limitations where the effluent limitations are described as:

TABLE D-15. PROMULGATED DRINKING WATER STANDARDS (40 CFR 141)

The following are the maximum contaminant levels for inorganic chemicals other than fluoride:

Contaminant	Level, mg/l
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.
Selenium	0.01
Silver	0.05

When the average of the maximum daily air temperatures for the location in which the community water system is situated is the following, the maximum contaminant levels for fluoride are:

Temperature, °F	°C	Level, mg/l
53.7 and below	12.0 and below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

The following are the maximum contaminant levels for organic chemicals. They apply only to community water systems. Compliance with maximum contaminant levels for organic chemicals is calculated pursuant to Section 141.24.

	Level, mg/l
a. Chlorinated hydrocarbons:	
Endrin (1,2,3,4,10, 10-hexachloro-6.7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1.4-endo-5,8-dimenthano naphthalene).	0.00002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer).	0.004
Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxyphenyl) ethane).	0.1
Toxaphene ($C_{10}H_{10}Cl_8$-Technical chlorinated camphene. 67-69 percent chlorine).	0.005
b. Chlorophenoxys:	
2,4-D, (2,4-Dichlorophenoxyacetic acid).	0.1
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid).	0.01

TABLE D-16. PROPOSED SECONDARY DRINKING WATER REGULATIONS[a]

Contaminant	Proposed level	Principal effects
Chloride	250 mg/l[b]	taste
Color	15 color units	appearance
Copper	1 mg/l	taste, fixture staining
Corrosivity	(Noncorrosive)	deterioration of pipes, unwanted metals in drinking water
Foaming agents	0.5 mg/l	foaming, adverse appearance
Hydrogen sulfide	0.05 mg/l	taste, brown stains on laundry and fixtures
Manganese	0.05 mg/l	taste brown stains, black precipitates
Odor	3 Threshold Odor Number	odor
pH	6.5 - 8.5	corrosion below 6.5 - incrustations, bitter taste, lowered germicidal activity of chlorine over 8.5
Sulfate	250 mg/l	taste, laxative effects
Total dissolved solids	500 mg/l	taste, reduction in life of hot water heaters, precipitations in cooking utensils
Zinc	5 mg/l	taste

[a] Recommended limits and principal effects associated with each contaminant.

[b] Milligrams per liter; same as "parts per million."

TABLE D-17. NEW SOURCE PERFORMANCE STANDARDS FOR "OIL SHALE RELATED FACILITIES"

40 CFR 60.40 Subpart D (NSPS for Fossil Fuel Fired Steam Generators)

TSP	0.10 pound per million Btu
SO_2	0.80 pound per million Btu (liquid fuel)
NO_x	0.20 pound per million Btu (gaseous fuel) 0.30 pound per million Btu (liquid fuel)

40 CFR 60.100 Subpart (NSPS for petroleum refineries)

H_2S	0.10 grain/dscf
HC	Floating roof or vapor recovery if true vapor pressure is >1.5 psia but <11.1 psia reporting requirements only if true vapor pressure is <1.5 psia.

40 CFR 60 (NSPS for Refinery Claus Sulfur Recovery Plants)

Gaseous fuel burning	0.1 grain/dscf
Sulfur recovery	
oxidation system	250 ppm SO_2
reduction system	300 ppm total S 10 ppm H_2S

Proposed NSPS

1. Gas Turbines >10 x 10^6 Btu/hour

   75 ppmv NO_x at 15% O_2
   150 ppmv SO_2

2. Coal Gasification (Guideline)

   250 ppmv total S
   99.0 percent total S removal
   100 ppmv HC

3. Field gas processing units

Gaseous fuel burning	160 ppmv H_2S
Sulfur recovery	250 ppmv SO_2 (oxidation) 300 ppmv S (reduction)

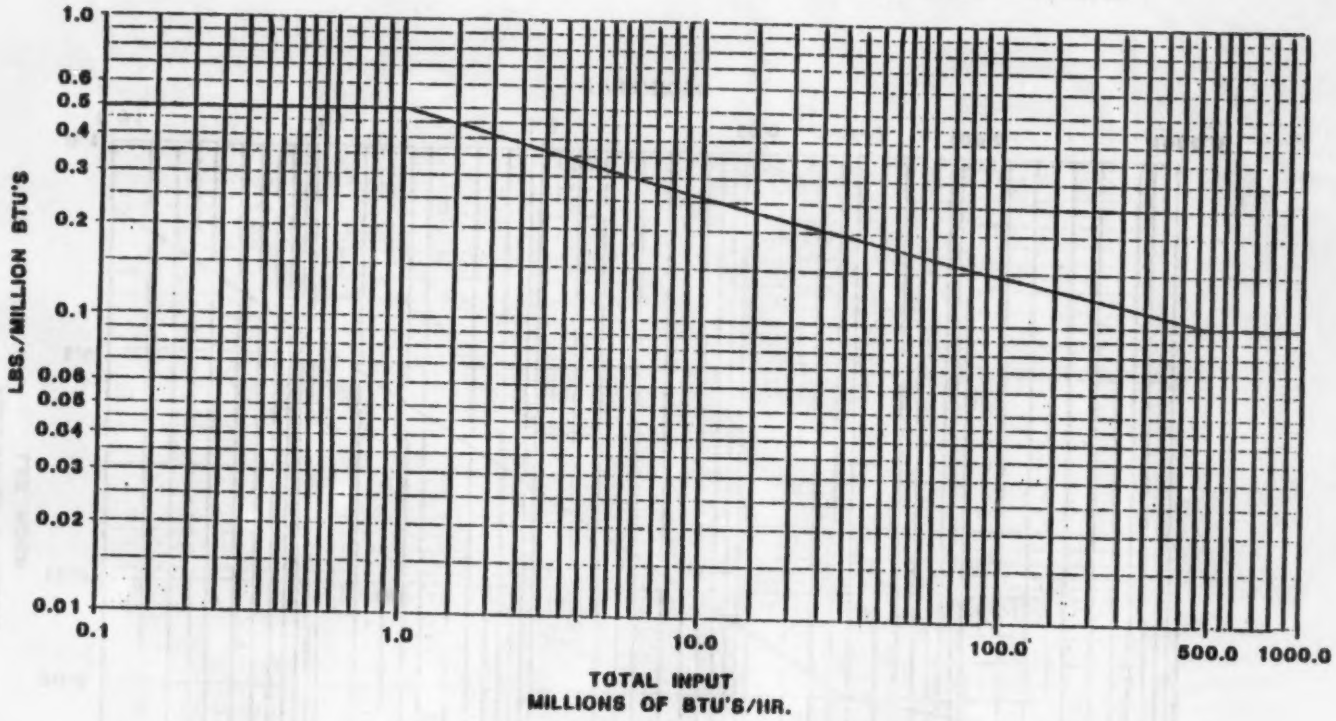

Figure D - 4. Fuel burning equipment - particulate emission.

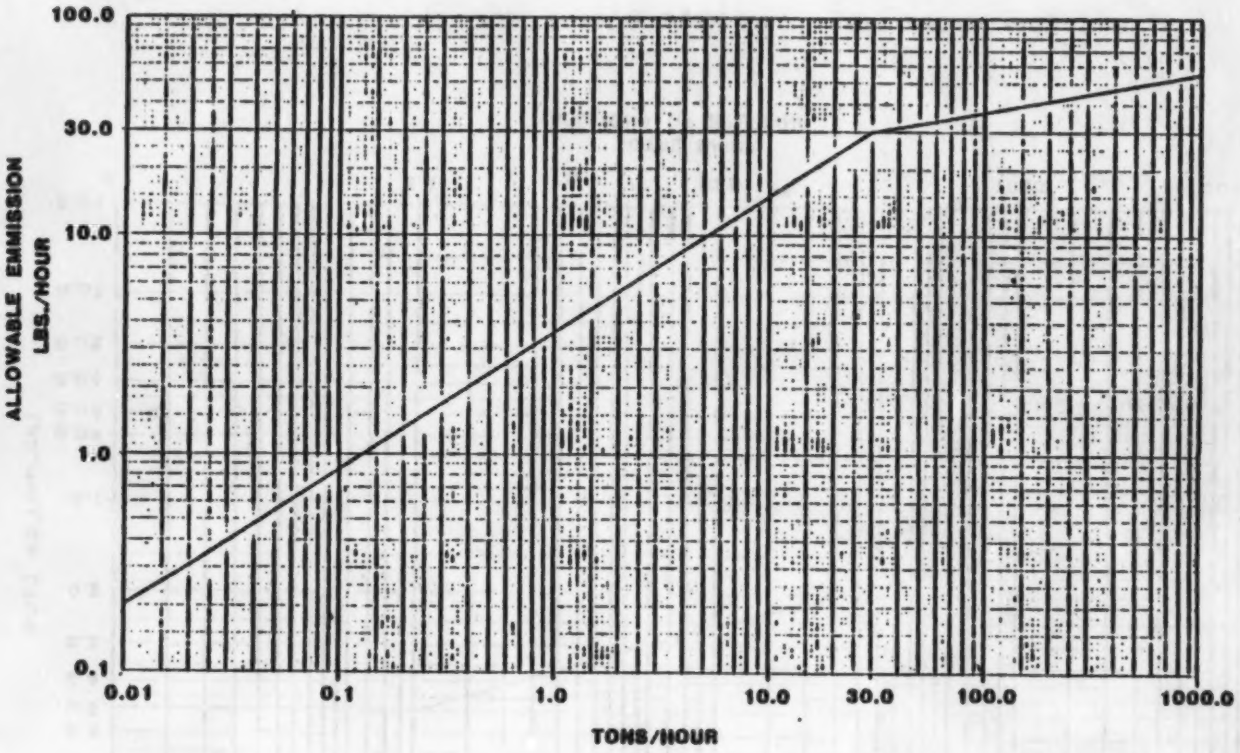

Figure D - 5. Process weight rate - particulate emission.

> ...restrictions on quantities, rates, and concentrations of chemical, physical, biological, and other constituents discharged from any discernible, confined, and discrete conveyance (point source) from which pollutants are or may be discharged.

These effluent limitations effectively allow water quality to be protected through the refined identification and development of water use and treatment procedures that are to be applied at the source of potential pollutants (i.e., the discharge itself). The Act (FWPCA) requires that:

> By 1 July 1977, there be achieved effluent limitations for point sources (excluding publicly-owned treatment works) which shall require the application of the best practicable control technology currently available (BPT).
>
> By 1 July 1977, there be developed pretreatment requirements for discharges of "noncompatible" pollutants to publicly-owned treatment works.
>
> By 1 July 1977, there be developed effluent limitations based upon secondary treatment in publicly-owned treatment works.
>
> By 1 July 1977, any more stringent limitations necessary to meet other laws must be achieved, including Water Quality Standards.
>
> By 1 July 1984, there must be achieved effluent limitations for point sources (other than publicly-owned treatment works) where application of the best available technology economically available (BAT) is required for nonconventional and toxic pollutants as defined in the Act.
>
> By 1 July 1984, there must be achieved effluent limitations for point sources where application of the best conventional pollutant control technology for conventional pollutant (TSS, pH, BOD, and fecal coliform).

The Act also established effluent requirements for toxic pollutants. BAT must be defined by July 1, 1980 for the 129 priority pollutants for the 21 industrial categories identified below. The present EPA schedule shows proposals for these categories are being completed by the end of 1980. Data for oil shale related facilities are shown in parentheses.

Automatic and Other Laundries
Coal Mining (12/80)
Electroplating
Inorganic Chemicals Manufacturing
Iron and Steel Manufacturing
Leather Tanning and Finishing
Machinery and Mechanical Products Manufacturing
Miscellaneous Chemicals Manufacturing
Nonferrous Metals Manufacturing
Ore Mining
Organic Chemicals Manufacturing
Point and Ink Formulation Printing
Paving and Roofing Materials
Petroleum Refining (5/80)

- Plastic and Synthetic Materials Manufacturing
- Pulp and Paperboard Mills and Converted Paper Products
- Rubber Processing
- Soap and Detergent Manufacturing
- Steam Electric Power Plants
- Textile Mill
- Timber Products Processing

Oil shale facilities are not one of the listed industries. However, compliance with BAT standards for individual toxic pollutants established pursuant to Section 307 must be met by July 1, 1984. Oil shale facilities must comply with any of these "307" standards. In the absence of BAT for the oil shale industry, BAT must be defined on the basis of best engineering judgement via the issuance of an individual NPDES permit. Table D-18 provides a schedule for implementing BAT and BCT.

The control of discharge of pollutants from point sources is accomplished through establishment and enforcement of effluent limitations. Enforcement of effluent limitations is carried out through the "National Pollutant Discharge Elimination System" (NPDES) as outlined in Sections 401 and 402 of the ACT (FWPCA). It is the intent that each state administer this program but in some cases the states have not yet passed required legislation and thus the program is administered by the EPA. In general, to accept the program the states must be able to prohibit discharges of permit requirements and must be able to administer the program. It is useful to note that in order to assume the NPDES program a state must also have procedures which control the disposal of pollutants into wells in order to protect the public health and welfare and to prevent pollution of ground and surface water resources. The program is being implemented by Colorado but not by Utah.

To better understand the NPDES program it is appropriate to quote some of the definitions used in the program. These definitions are:

> "The term pollutant means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. Excluded is water, gas, or other material injected into a well to facilitate production of oil, gas, or produced water disposed of in a well if the latter is approved."

Point source is defined to mean:

> ...Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel, or other floating craft from which pollutants are or may be discharged.

Navigable waters are defined as including:

1. All navigable waters of the United States

TABLE D-18. LEVELS OF CONTROL APPLICABLE TO EXISTING SOURCES UNDER 1977 AMENDMENTS TO FWPCA

Pollutant	Conventional	Nonconventional	Toxic		
Name	Best Conventional Pollutant Control Technology	Best Available Technology Economically Achievable	Best Available Technology Economically Achievable	Effluent Standards (or Prohibitions)	Best Management Practices
Abbreviation	BCT	BAT	BAT		BMP's
Statutory Deadline	July 1, 1984	July 1, 1984/as appropriate.[a] Never later than July 1, 1987	July 1, 1984/as appropriate[b]	Up to one year after promulgation/as appropriate[c]	None
301(c) Economic Variance	No	Yes	No	No	No
301 (g) Environmental Variance	No	Yes	No	No	No

[a] July 1, 1984, or three years after limitations are established, whichever is later. Never later than July 1, 1987.

[b] July 1, 1984 for those 129 toxic pollutants which appeared at 43 Federal Register 4108 (January 30, 1978). For other pollutants which may be added to the toxics list, three years after limitations for such pollutants are established.

[c] The effective date for an effluent standard for a toxic pollutant may be extended to three years after the standard is promulgated if earlier compliance is technically infeasible.

2. Tributaries of navigable waters of the United States

3. Interstate waters

4. Intrastate lakes, rivers, and streams which are utilized by interstate travelers for recreational or other purposes

5. Intrastate lakes, rivers, and streams from which fish or shellfish are taken and sold in interstate commerce

6. Intrastate lakes, rivers, and streams which are utilized for industrial purposes by industries in interstate commerce

The term "effluent limitation" means any restriction established by State or the Administrator of quantities, rates, and concentration of chemical, physical, biological, and other constituents which are discharged from point sources into navigable waters, the waters of the contiguous zone, or the ocean, including schedules of compliance.

The term "discharge of a pollutant" means any addition of any man-made or man-induced material which alters the chemical, physical, biological, and radiological interity of a navigable water. Not much is left out--so, it is best to assume that if there is or may be a discharge, a permit must be applied for. One should stress the "may be" component. It is not uncommon in the West to assume that retention facilities will not discharge and then find that an unusual precipitation event threatens the integrity of the system since no discharge was assumed.

Establishment of effluent guidelines and standards is addressed in "Title III - Standards and Enforcement" of the Act (FWPCA). Effluent limitations for existing point sources are discussed in Section 302. It is required that when, in the judgment of the Administrator, the discharge of pollutants from a point source would interfere with the attainment or maintenance of water quality under the provisions of the Act, effluent limitations (including alternate effluent control strategies) for such point sources shall be established.

Section 306 of Title III required the Adminstrator to propose, publish, review and revise when appropriate, standards of performance for new sources (sources whose construction is commenced after publication of the regulation). A minimum of 28 industrial categories (Group I) was identified. Although oil shale facilities were not identified, petroleum refinery BAT, BPT, and NSPS may serve as guidelines.

For Petroleum Refining as a whole the significant waste water constituents identified as BOD_5, COD, TOC, TSS, oil and grease, phenolic compounds, ammonia (N), sulfides, and total and hexavalent chromium and were subsequently selected as the basis for the effluent limitations.

Best Practicable Control Technology Currently Available (BPT) was based upon the following treatment procedures:

- Sour water stripping to reduce ammonia and sulfide

- Elimination of once-through barometric condenser water
- Segregation of sewers
- Elimination of polluted once-through cooling water
- Oil and solids removal at end of pipe
- Carbonaceous wastes removal at end of pipe

BPT effluent limits established in 40 CFR 419.52 are shown in Table D-19.

Best Available Technology Economically Achievable (BAT) was defined in the context of using additional treatment methods now practiced by some plants in the petroleum refining industry, and include:

1. Use of air cooling equipment.
2. Reuse of sour water stripper bottoms in crude desalters.
3. Reuse of once-through cooling water as make-up to the water treatment plant.
4. Using wastewater treatment plant effluent as coolant water, scrubber water, and influent to the water treatment plant.
5. Reuse of boiler condensate as boiler feedwater.
6. Recycle of water from coking operations.
7. Recycle of waste acids from alkylation units.
8. Recycle of overhead water in water washes.
9. Reuse of overhead accumulator water in desalters.
10. Use of closed compressor and pump cooling water system.
11. Reuse of heated water from the vacuum overhead condensers to heat the crude. This reduced the amount of cooling water needed.
12. Use of rain runoff as cooling tower make-up or water treatment plant feed.

The numerical effluent limitations for BAT published at 40 CFR 419.53 are shown in Table D-20.

New source standards (NSPS) represent controls that are equal to or better than BAT (Table D-21). Sources are subject to NSPS if they have not commenced construction prior to the proposal of NSPS. Oil shale NSPS have not yet been proposed.

TABLE D-19. BPT EFFLUENT LIMITS AS ESTABLISHED IN 40 CFR 419.52

	Effluent limitations			
Effluent characteristic	Maximum for any 1 day	Average of daily values of 30 consecutive days shall not exceed	Maximum for any 1 day	Average of daily values of 30 consecutive days shall not exceed
	Metric units (kg per 1,000 m^3 of feedstock)		English units (pounds per 1,000 bbl of feedstock)	
BOD_5	54.4	28.9	19.2	10.2
TSS	37.3	23.7	13.2	8.4
COD	388	198	136	70
Oil and grease	17.1	9.1	6.0	3.2
Phenolic compounds	0.40	0.192	0.14	0.068
Ammonia as N	23.4	10.6	8.3	3.8
Sulfide	0.35	0.158	0.124	0.056
Total chromium	0.82	0.48	0.29	0.17
Hexavalent chromium	0.068	0.032	0.025	0.011
pH	Within the range of 6.0 to 9.0		Within the range of 6.0 to 9.0	

TABLE D-20. BAT EFFLUENT LIMITATIONS PER 40 CFR 419.53

	Effluent limitations			
Effluent characteristics	Maximum for any 1 day	Average of daily values of 30 consecutive days shall not exceed	Maximum for any 1 day	Average of daily values of 30 consecutive days shall not exceed
	Metric units (kg per 1,000 m^3 of feedstock)		English units (pounds per 1,000 bbl of feedstock)	
BOD_5	8.8	7.1	3.2	2.6
TSS	8.4	7.1	3.0	2.6
COD	47	38	16.8	13.4
Oil and grease	1.7	1.4	0.60	0.48
Phenolic compounds	0.041	0.029	0.015	0.010
Ammonia as N	5.6	4.2	2.0	1.5
Sulfide	0.19	0.12	0.066	0.042
Total chromium	0.44	0.37	0.15	0.13
Hexavalent chromium	0.0092	0.0059	0.0033	0.0021
pH	Within the range of 6.0 to 9.0		Within the range of 6.0 to 9.0	

TABLE D-21. REFINERY NEW SOURCE PERFORMANCE STANDARDS AS PER 40 CFR 419.55

	Effluent limitations			
	Maximum for any 1 day	Average of daily values of 30 consecutive days shall not exceed	Maximum for any 1 day	Average of daily values of 30 consecutive days shall not exceed
	Metric units (kg per 1,000 m^3 of feedstock)		English units (pounds per 1,000 bbl of feedstock)	
BOD_5	41.6	22.1	14.7	7.8
TSS	28.1	17.9	9.9	6.3
COD	295	152	104	54
Oil and grease	12.6	6.7	4.5	2.4
Phenolic compounds	0.30	0.14	0.105	0.051
Ammonia as N	23.4	10.7	8.3	3.8
Sulfide	0.26	0.12	0.093	0.042
Total chromium	0.64	0.37	0.220	0.13
Hexavalent chromium	0.052	0.024	0.019	0.0084
pH	Within the range of 6.0 to 9.0		Within the range of 6.0 to 9.0	

New sources must meet standards of performance (for the control of the discharge of pollutants) which reflect the greatest degree of effluent reduction which the EPA Administrator determines to be achievable through application of the best available demonstrated control technology, processes operating methods or other alternatives including, where practicable, no discharge of pollutants . A "no discharge of process waste water pollutants" may be considered in any stage of effluent limitations development.

Water quality as affected by thermal discharges is addressed in Section 316 of the Act. Any point source subject to the provisions of Section 301 "Effluent Limitations" or Section 306 "National Standards of Performance" may attempt to demonstrate that any proposed effluent limitation for thermal control of a discharge is more stringent than necessary to assure the protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife in and on the receiving body of water. Based on such demonstration, the Administrator (or, if appropriate, the State) may impose an alternate limitation (316a).

Any standard established pursuant to the requirements of the Act shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impacts (316b).

Notwithstanding any other provisions of the Act, any point source modified after the enactment of the Act (FWPCA) to meet required thermal effluent limitations shall not be subject to more stringent thermal limitations during a 10-year period from date of modification or during the period of depreciation of the facility, whichever comes first.

EPA is in the process of defining industry specific and compound specific effluent limitations for the 129 "priority" pollutants. Table D-22 lists these pollutants.

TABLE D-22. LIST OF 129 SPECIFIC POLLUTANTS COMPOUND NAME

1. *acenaphthane
2. *acrolein
3. *acrylonitrile
4. *benzene
5. *benzidine
6. *carbon tetrachloride (tetrachlormethane)

*Chlorinated benzenes (other than dichlorobenzenes):

7. chlorobenzene
8. 1,2,4-trichlorobenzene
9. hexachlorobenzene

*Chlorinated ethanes (including 1,2-dichlorethane, 1,1,1-trichloroethane and hexachloroethane)

10. 1,2-dichloroethane
11. 1,1,1-trichloroethane
12. hexachloroethane
13. 1,1-dichloroethane
14. 1,2,2-trichloroethane
15. 1,1,2,2-tetrachloroethane
16. chloroethane

*Chloroalkyl ethers (chloromethyl, chloroethyl and mixed ethers):

17. bis (chloromethyl) ether
18. bis (2-chloroethyl) ether
19. 2-chloroethyl vinyl ether (mixed)

*Chlorinated naphthalenes:

20. 2-chloronaphthalene

*Chlorinated phenols (other than those listed elsewhere; includes trichlorophenols and chlorinated cresols):

21. 2,4,6-trichlorophenol
22. parachlorometa cresol
23. *chloroform (trichloromehtane)
24. *2-chlorophenol

*Dichlorobenzenes:

25. 1,2-dichlorobenzene
26. 1,3-dichlorobenzene
27. 1,4-dichlorobenzene

*Dichlorobenzidine:

28. 3,3-dichlorobenzidine

*Dichloroethylenes (1,1-dichloroethylene and 1,2-dichloroethylene):

29. 1,1-dichloroethylene
30. 1,2-trans-dichloroethylene
31. *2,4-dichlorophenol

*Dichloropropane and dichloropropene:

32. 1,2-dichloropropane
33. 1,2-dichloropropylene (1,3-dichloropropene)
34. *2,4-dimethylphenol

*Dinitrotoluene:

35. 2,4-dinitrotoluene
36. 2,6-dinitrotoluene
37. *1,2-diphenlyhydrazine
38. *ethylbenzene
39. *fluoranthene

*Haloethers (other than those listed elsewhere)

40. 4-chlorophenyl phenyl ether
41. 4-bromophenyl phenyl ether
42. bis (2-chlorosopropyl) ether
43. bis (2-chloroethoxy) methane

*Halomethanes (other than those listed elsewhere)

44. methylene chloride (dichloromethane)
45. methyl chloride (chloromethane)
46. methyl bromide (bromomethane)
47. bromoform (tribromomethane)
48. dichlorobromomethane
49. trichlorofluoromethane
50. dichlorodifluoromethane
51. chlorodibromomethane
52. *hexachlorobutadiene
53. *hexachlorocyclopentadiene
54. *isophorone
55. *naphthalene
56. *nitrobenzene

*Nitrophenols (including 2,4-dinitrophenol and dinitrocresol):

57. 2-nitrophenol
58. 4-nitrophenol
59. *2,4-dinitrophenol
60. 4,6-dinitro-o-cresol

*Nitrosamines:

61. N-nitrosodimethylamine
62. N-nitrosodiphenylamine
63. N-nitrosodi-n-propylamine
64. *pentachlorophenol
65. *phenol

*Phthalate esters:

66. bis (2-ethylhexyl) phthalate
67. butyl benzyl phthalate
68. di-n-butyl phthalate
69. di-n-octyl phthalate
70. diethyl phthalate
71. dimethyl phthalate

*Polynuclear aromatic hydrocarbons:

72. benzo (a) anthracene (1,2-benzanthracene)
73. benzo (a) pyrene (3,4-benzopyrene)
74. 3,4-benzofluoranthene
75. benzo (k) fluoranthane (11,12-benzofluoranthene)
76. chrysene
77. acenaphthylene
78. anthracene
79. benzo (ghi) perylene (1,2-benzoperylene)
80. fluorene
81. phenathrene
82. dibenzo (a-h) anthracene (1,2,5,6-dibenzathracene)
83. indeno (1,2,3-cd) pyrene (2,3-o-phenylenepyrene)
84. pyrene
85. *tetrachloroethylene
86. *toluene
87. *trichloroethylene
88. *vinyl chloride (chloroethylene)

Pesticides and Metabolites:

89. *aldrin
90. *dieldrin
91. *chlordane (technical mixture & metabolites)

*DDT and metabolites

92. 4,4'-DDT
93. 4,4'-DDE (p-p'-DDX)
94. 4,4'-DDD (p,p'-TDE)

*endosulfan and metabolites

95. a-endosulfan-Alpha
96. b-endosulfan-Beta
97. endosulfan sulfate

*endrin and metabolites

(continued)

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TABLE D-22. (continued)

98. endrin
99. endrin aldehyde
*heptachlor and metabolites:
100. heptachlor
101. heptachlor epoxide
*hexachlorocyclohexane (all isomers)
102. a-BHC-Alpha
103. b-BHC-Beta
104. r-BHC (lindane)-Gamma
105. g-BHC-Delta
*polychlorinated biphenyls (PCB's):
106. PCB-1242 (Arochlor 1242)
107. PCB-1254 (Arochlor 1254)
108. PCB-1221 (Arochlor 1221)
109. PCB-1232 (Arochlor 1232)
110. PCB-1248 (Arochlor 1248)
111. PCB-1260 (Arochlor 1260)
113. *Toxaphene
114. *Antimony (Total)
115. *Arsenic (Total)
116. *Asbestos (Fibrous)
117. *Beryllium (Total)
118. *Cadmium (Total)
119. *Chromium (Total)
120. *Copper (Total)
121. *Cyanide (Total)
122. *Lead (Total)
123. *Mercury (Total)
124. *Nickel (Total)
125. *Selenium (Total)
126. *Silver (Total)
127. *Thallium (Total)
128. *Zinc (Total)
129. **2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

APPENDIX E

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APPENDIX F

FEDERAL AND STATE PERMITS REQUIRED FOR OPERATION OF AN OIL SHALE FACILITY

Operation of an oil shale facility requires the filing of dozens of permits from Federal, State, and local government agencies. Because of varied and overlapping regulations and statutes, it is often difficult to know which agencies to contact and what permits are required.

This appendix was designed to be used as a guide for prospective oil shale operators and government officials who may not be aware of the requirements and their respective governing agencies. This appendix provides information on the major permit and approval requirements from Federal agencies, the States of Colorado, Utah, and Wyoming, and appropriate local agencies. A basis for this section was provided by lists of permits and approvals applied for by oil shale Tracts U-a and U-b, C-a and C-b, the Colony Development Operation, and through discussions with Federal and State personnel in charge of permit applications.

Though this appendix may not be entirely complete, it is a base from which to start when filing all needed requirements. A complete permit program can only be accomplished when all details of an individual operation are known. Each operation varies in its requirements, and operators must work closely with government agencies throughout all phases of operation.

Before construction of any operation, it is recommended that the operator contact the following lead agencies for further information:

Colorado:

Executive Director
Department of Natural Resources
1313 Sherman Street
Denver, Colorado 80203
(303) 839-3311

Executive Director
Colorado Department of Health
Air Pollution Control Division
4210 E. 11th Avenue
Denver, Colorado 80220
(303) 320-8333

Wyoming:

Department Director
Department of Environmental Quality
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7391

Utah:

Executive Director
Department of Natural Resources
438 State Capitol
Salt Lake City, Utah 84114
(801) 533-5356

Federal:

Regional Administrator
U.S. Environmental Protection Agency
Region VIII
1860 Lincoln Street
Denver, Colorado 80203

U. S. Department of Energy
Regional Office
1075 South Yukon Street
P. O. Box 26247
Belmar Branch
Lakewood, Colorado 80226
(303) 234-2420

Garfield County, Colorado:

Ray Baldwin, Planning Director
GCP Department
2014 Blake Street
Glenwood Springs, Colorado 81601
(303) 945-8212

Rio Blanco County, Colorado:
Glen Payne, County Planner
RBCP Department
P. O. Box 599
Meeker, Colorado 81641
(303) 878-5081

Uintah County, Utah:
Jess Miller, Administrator
Uintah County, Planning and Zoning Board
220 South 500 East
Vernal, Utah 84078
(801) 789-4382

Sweetwater County, Wyoming:
Dennis Watt, Planning Director
Sweetwater County Planning Department
P. O. Box 791
Green River, Wyoming 82935
(307) 875-2611, ext. 270

OIL SHALE PERMIT

PERMIT TITLE

Occupational Safety and Health Regulations

JURISDICTION

Federal

LEGAL CITATION

29 CFR 1900-1999

RESPONSIBLE AGENCY/CONTACT

U.S. Department of Labor (303) 837-3883
Occupational Safety and Health
Administration
Region VIII Office
1961 Stout Street, Room 15010
Denver, Colorado 80202

ABSTRACT The Occupational Safety and Health Administration (OSHA) was established in 1970 by PL 91-596; 29 USC 651-678 (the Williams-Steiger OS&H Act). This Act affects all companies except self-employed perons. Small businesses (fewer than 10 employees) do not have to keep records but are still affected by the regulations. These standards do not apply to conditions subject to other Federal regulations, although this does not exempt production on Federal Leases administered by USGS.

OSHA encourages States to assume responsibility for administration of OS&H programs. The Federal law permits any State to assert jurisdiciton, under State law, over any occupational or health standard not covered by a Federal standard. Any State may also assume responsibility for development and enforcement of its own standards for those areas now covered by Federal standards. Colorado, Utah, and Wyoming have State standards approved by OSHA, and therefore, the State offices must be contacted. The Region VIII office can tell you whom to contact for specific State requirements.

SCHEDULING MILESTONES

Depends on regulations requirements.

PERMIT APPLICATION LEAD TIME

Depends on requirements.

OIL SHALE PERMIT

PERMIT TITLE

Environmental Impact Statement (EIS)

JURISDICTION

Federal

LEGAL CITATION

P.L. 91-190, 43 U.S.C. 4321 et seq. (NEPA), 83 Stat. 852-856.

RESPONSIBLE AGENCY/CONTACT

U.S. EPA, Region VIII (303) 837-4831
Mr. J. William Geise, Chief
Environmental Evaluation Board
1860 Lincoln Street
Denver, Colorado 80295

U.S. Environmental Protection Agency
Mr. Peter Cook, Director (202) 755-0790
Office of Federal Activities
Room 537 West Tower
407 M Street, SW
Washington, D.C. 20460

ABSTRACT

The National Environmental Policy Act (NEPA) directs all Federal agencies to identify and develop methods and procedures that will ensure that presently unquantified environmental amenities and values are given appropriate consideration in decisionmaking along with economic and technical considerations. The act directs that all agencies prepare a detailed statement on all actions significantly affecting the quality of the human environment. The statement is required to include:

- The environmental impact of the proposed action,
- Any adverse environmental effects that cannot be avoided should the proposal be implemented.
- Alternatives to the proposed action,
- The relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
- Any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

The act originally established that the President report to Congress annually concerning the environmental quality of the Nation, it also established the Council on Environmental Quality (CEQ), which was deemed responsible for the review of environmental impact statements. In 1977, under President Carter's government reorganization, the CEQ staff of 40 was virtually eliminated. EIS review responsibilities are now handled by EPA, and the remaining CEQ personnel are acting in an advisory fashion on environmental policies.

SCHEDULING MILESTONES

A draft statement is prepared under guidlines set forth in P.L. 91-190 Section 102(2)(C). Comments will be incorporated into a final statement. The agencies who will review the EIS depend on its nature. Scheduling depends on the complexity of the statement. Timing will vary from 6 months to 2 or more years.

PERMIT APPLICATION LEAD TIME

2 to 3 years.

OIL SHALE PERMIT

PERMIT TITLE	**JURISDICTION**
Resource Recovery and Conservation—definition and control	Federal

LEGAL CITATION

Resource Recovery and Conservation Act of 1976. P.L. 94-580 42 U.S.C. 3251 et. seq. as amended.

RESPONSIBLE AGENCY/CONTACT

U.S. Environmental Protection Agency
Mr. Hank Schroeder - (303) 837-2221
Waste Management Branch
Region VIII
1860 Lincoln Street, Suite 900
Denver, Colorado 80203

ABSTRACT The overall objectives are to promote the protection of health and the environment and to conserve material and energy resources by establishing a cooperative effort toward improving solid waste management among Federal, State, and local governments and private enterprise. The protection of health and the environmental includes runoff, protection of air quality, disease and vector control, safety, and esthetics associated with land disposal sites.

Provisions in the act call for integration with, but not duplication of, the requirements set forth by provisions of the Clean Air Act, the Federal Water Pollution Control Act, the Federal Insecticide, Fungicide and Rodenticide Act, the Hazardous Materials Transportation Act, and other acts as grant regulatory authority to the EPA Administrator.

Final RCRA regulations appeared in the Federal Register on February 26 and May 19, 1980. Spent shale previously suspected of being labled "hazardous", is now classified as a "solid" waste due to a ten-fold increase in leachate toxicity levels. Thus, spent shale is now not applicable to RCRA regulations. In the future, after more research is conducted, the RCRA mutagenicity test may affect oil shale.

SCHEDULING MILESTONES

Regulations pertaining to RCRA permit requirements are contained in the Consolidated Permit regulations published in the May 19, 1980, Federal Register.

PERMIT APPLICATION LEAD TIME

None at this time.

OIL SHALE PERMIT

PERMIT TITLE

Toxic Substances--definition and control

JURISDICTION

Federal

LEGAL CITATION

Toxic Substances Control Act (P.L. 94-469)
(90 Stat. 2003; 15 U.S.C. 2601 et. seq.)

RESPONSIBLE AGENCY/CONTACT

Mr. Lou Johnson
Toxic Substances Branch
Environmental Protection Agency
1860 Lincoln Street
Denver, Colorado 80203
(303) 837-3926

Mr. John B. Ritch Jr.
Director, Office of Industry Assistance
Office of Toxic Substances TS-788
Environmental Protection Agency
401 M. Street S.W.
Washington, D.C. 20460
(202) 755-0535

ABSTRACT The Act requires that the EPA compile a list that includes each chemical substance that was manufactured or processed in the United States in quantities greater than 100,000 lbs in 1977, and that is being sold in commerce.

If the chemical is not being sold in commerce by the producer, it is classified as an R&D substance and does not need to be listed. If a company now under the R&D criterion begins to market the chemical, it would then come under the pre-manufacturing criterion. Manufacturers of new chemical substances must give EPA 90 days notice before manufacture of the substance. Any substance not listed on EPA's inventory of existing chemicals is considered "new" for purposes of the premarket notice requirement.

An initial inventory listing over 44,000 commercially produced chemical substances was published in the May 15, 1979 Federal Register. Ten synthetic fuels were identified on this list, including shale oil. Being on the list does not "protect" a product from possible control requirements.

EPA may prohibit or limit the manufacturing, processing, distribution, or use in commerce of any substance that EPA finds to present risk of injury to health or the environment. Manufacturers are required to keep records of the processes used and to conduct tests to assure compliance with regulations. EPA can, if necessary, go to Federal district court and seek an injunction to block production of a chemical until test results are completed. Civil penalties are possible for violations.

SCHEDULING MILESTONES

Not applicable

PERMIT APPLICATION LEAD TIME

Not applicable

OIL SHALE PERMIT

PERMIT TITLE

National Pollutant Discharge Elimination Systems (NPDES)

JURISDICTION

Federal

LEGAL CITATION

The Federal Water Pollution Control Act (P.L. 95-217), Section 402

RESPONSIBLE AGENCY/CONTACT

Mr. Bob Burm
Consolidated Permits
Environmental Protection Agency
1860 Lincoln Street, Suite 900
Denver, Colorado 80295
(303) 837-4901

ABSTRACT An NPDES permit must be obtained under requirements of Section 402 of the Act if water is discharged to a navigable stream. Specific New Source Performance Standards (NSPS) have not yet been promulgated for the oil shale industry. However, in their absence NPDES effluent limits are established on a best engineering basis. NSPS for the oil shale industry are scheduled to be promulgated 30 months after completion of all EPA guidance documents on the industry. Currently this is scheduled for April 1981, putting promulgation of the NSPS in 1983-1984. It should also be noted that through litigation, the definition of an NPDES permit has been changed from an operations permit to a construction permit in the case of a new source.

In situations where a permit is issued prior to the publication of the effluent guidelines, such as in oil shale, there is considerable flexibility in the determination of the precise effluent limitations which will be mandated by the permit. At the present time, petroleum refining industry guidelines give an indication of potential oil shale guidelines. Even after promulgation guidelines, the applicant may seek modification of limits in the permit by means of a variance clause. A careful engineering analysis of proposed permit limits is definitely required.

Procedural requirements for the NPDES permit program and parts of the EPA toxic pollutant strategy are implemented under the Consolidated Permit regulations.

SCHEDULING MILESTONES Applications for proposed new discharges must apply at least 180 days before the date the discharge is due to begin, unless a delay is granted by the approved State agency or by EPA. Permits may be issued for up to a five-year period. Reapplication and existing permits are covered under 40 CFR 122.53.

PERMIT APPLICATION LEAD TIME

180 days.

OIL SHALE PERMIT

PERMIT TITLE

Prevention of Significant Air Quality Deterioration

JURISDICTION

Federal

LEGAL CITATION

The Clean Air Act Amendments of 1977 (Pub. L. 95-95) CFR Title 40, Part 51.24.

RESPONSIBLE AGENCY/CONTACT

EPA Region VIII
Mr. John Dale, Director
Air and Hazardous Materials Division
1860 Lincoln Street, Suite 900
Denver, Colorado 80295
(303) 837-3763

ABSTRACT

On December 5, 1974, EPA published regulations under the 1970 version of the Clean Air Act (Pb. L. 91-604) for the prevention of significant air quality deterioration (PSD). These regulations, codified at 40 CFR 52.51, established a program for protecting areas with air quality cleaner than the national ambient air quality standards (NAAQS). Congress sanctified and modified the PSD concept in P.L. 95-95.

Under EPA's regulatory program, clean areas of the Nation are designated under any of three classes. Specified numerical increments of air pollution are permitted under each class up to a level considered to be significant for that area. Class I increments permit only minor air quality deterioration; class II increments, moderate deterioration; and class III increments, deterioration up to 50% of the secondary NAAQS. In general, national parks, wilderness areas, memorial parks, and international parks are permanently designated as Class I areas, and all other clean air areas are designated Class II. Provisions are included for redesignating an area to a higher or lower classification. All sources subject to PSD review must employ Best Available Control Technology (BACT) of controlled air pollutant emissions greater than 100 tons per year.

Topics of concern to States choosing to develop their own PSD programs are discussed in the rulemaking found in PSD program 40 CFR 52.51. Thus the two rules, 40 CFR 52, and 40 CFR 51, should be read together to determine whether an EPA permit is required in addition to the State permit.

SCHEDULING MILESTONES

At present, air quality monitoring guidelines do not exist for oil shale. EPA Region VIII is currently granting oil shale PSD permits on a case-by-case basis. Also, PSD permits are now subject to the Consolidated Permit Regulations.

PERMIT APPLICATION LEAD TIME

One year maximum (average is 6 months).

OIL SHALE PERMIT

PERMIT TITLE

Spill Prevention Control and Countermeasure (SPCC)

JURISDICTION

Federal

LEGAL CITATION Reference: See Federal Register Tuesday, December 11, 1973, Vol. 38, No. 237

RESPONSIBLE AGENCY/CONTACT

U.S. Environmental Protection Agency
Region VIII
Emergency Planning and Response Branch
1860 Lincoln Street
Denver, Colorado 80203
(303) 837-2468

ABSTRACT The two important sections under this requirement pertain to applicability (Sec. 102.1) and to guidelines for development of the plan (Sec. 112.7).

The requirement applies to oil storage or production (extraction) in excess of 660 gal. that has the potential of spillage into surface waterways. If there is no waterway in the area that may be affected, then a plan is not necessary.

Generally, the guidelines for such a plan include: (1) discussion of previous spills and their means of correction, (2) probable spills, including what quantity and type of oil may be lost and where it may flow, (3) and what specific steps to be taken for secondary containment. The plan is usually implemented by construction of dams, dikes, or other diversion measures.

Other requirements include: (1) commitment of management approval that converson facilities will be constructed, and (2) certification of plans by a registered professional engineer.

The plan is kept on file at the facility office where the oil is stored. A copy does not go to EPA. Review of the plan will be made during onsite inspection of the facility if and when a failure (spill) occurs.

SCHEDULING MILESTONES

Preparation of plans only.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Underground Injection Control—definition and control

JURISDICTION

Federal

LEGAL CITATION

Safe Water Drinking Act, 42 U.S.C. Section 300f et. seq.

RESPONSIBLE AGENCY/CONTACT

U.S. Environmental Protection Agency
Mr. Paul Osborne
Region VIII
1860 Lincoln Street
Denver, Colorado 80203
(303) 837-2731

ABSTRACT

Under the UIC Program, states will be given authority for enforcement under a state approval plan 40 CFR Part 123.7. State programs must be submitted to the EPA within 270 days after promulgation of the final Consolidated Permit regulations.

The program is divided into five classes of wells. Class III wells include in situ/oil shale operations. All wells existing before the rules are finalized must be repermitted within five years of the final program (40 CFR Part 122.37) New wells must be permitted under the applicable UIC Program (40 CFR Part 122.36). Permits are required for both in situ operation and for mine dewatering reinjection. The State of Colorado also requires reinjection permits under existing regulations.

Monitoring (40 CFR 146.34) and mitigation measures (40 CFR 122.42) to prevent the endangerment of the groundwater system are requirements under these regulations. Monitoring requirements will include: testing of physical and chemical data with sufficient frequency to yield representative data; installation of continuous recording devices for injection pressure, flow rate and volume; demonstration of mechanical integrity at least every five years; weekly monitoring of fluid level and water quality in the monitoring wells; quarterly monitoring of any water supply wells adjacent to the site; and maintenance of the required monitoring results for three years.

SCHEDULING MILESTONES

Application for existing injection wells must be submitted no later than 4 years after approval of UIC program. For new wells, a "reasonable" time before construction begins.

PERMIT APPLICATION LEAD TIME

For new wells, if permit lead time is not long enough, a temporary permit may be granted for 90 days.

OIL SHALE PERMIT

PERMIT TITLE

Consolidated Permit Regulations

JURISDICTION

Federal

LEGAL CITATION

40 CFR Parts 122, 123, 124, and 125

RESPONSIBLE AGENCY/CONTACT

U.S. Environmental Protection Agency
Mr. Bob Burm, Consolidated Permits
1860 Lincoln Street, Suite 900
Denver, Colorado 80295
(303) 837-4901

ABSTRACT This rule establishes consolidated permit program requirements governing the Hazardous Waste Management program under the Resource Conservation and Recovery Act (RCRA), the Underground Injection Control (UIC) program under the Safe Drinking Water Act (SDWA), the National Pollutant Discharge Elimination System (NPDES) program and State Dredge or Fill ("404") programs under the Clean Water Act (CWA), and the Prevention of Significant Deterioration (PSD) program under the Clean Air Act, for three primary purposes:

(1) To consolidate program requirements for the RCRA and UIC programs with those already established for the NPDES program.

(2) To establish requirements for State programs under the RCRA, UIC, and Section 404 programs.

(3) To consolidate permit issuance procedures for EPA-issued Prevention of Significant Deterioration permits under the Clean Air Act with those for the RCRA, UIC, and NPDES programs.

These regulations shall become effective as follows: All regulations shall become effective as to UIC permits and programs July 18, 1980, but shall not be implemented until the effective date of 40 CFR Part 146. All regulations shall become effective as to RCRA permits and programs November 19, 1980. All other provisions of the regulations shall become effective July 18, 1980.

SCHEDULING MILESTONES

See individual permit discussions.

PERMIT APPLICATION LEAD TIME

See individual permit discussions.

OIL SHALE PERMIT

PERMIT TITLE

Dredge and Fill Permit

JURISDICTION

Federal

LEGAL CITATION

Section 404 of P.L. 92-500, 33 CFR Sections 322.4 and 323.4.

RESPONSIBLE AGENCY/CONTACT

U.S. Army District—Sacramento
Operations Division
404 Permit Section
650 Capitol Mall
Sacramento, California 95814
(916) 440-2232

ABSTRACT

Section 404 of the Clean Water Act authorizes the Corps of Engineers to issue permits for the discharge of dredged or fill material into the navigable waters at specified disposal sites. Although this most obviously applies to the disposal of spoil from dredging navigation channels, the authority also extends to every situation where a pile is driven or any other structure installed in the navigable waters. Statutory responsibility for the total program is divided between the Corps and EPA. Sections 404(b) and (c) of the Clean Water Act empower EPA to issue criteria for the selection of environmentally acceptable disposal sites and to prohibit the selection of any individual area if it is environmentally not acceptable.

Specific activities are exempt from permit requirements, including normal agricultural, silvicultural and ranching operations, maintenance of dams and levees, and construction or maintenance of farm ponds and forestry roads. With respect to permits for industrial projects, however, the Corps of Engineers clearly plays the dominant role.

Permits may be individual permits authorizing a single specified discharge, or general permits authorizing specified types of discharges in a specified waterway for group of waterways. Nationwide permits have been issued for discharges of dredged or fill material into certain smaller or minor waters of the United States and for certain types of activities in all waters of the United States.

SCHEDULING MILESTONES

Allow 90 days minimum barring public objections. Public notice and public hearings are required if there are objections. A complicated permit could take a year or more for approval.

PERMIT APPLICATION LEAD TIME

90 days.

OIL SHALE PERMIT

PERMIT TITLE

Major Fuel Burning Installation Approval

JURISDICTION

Federal

LEGAL CITATION

10 CFR 303-309

RESPONSIBLE AGENCY/CONTACT

U.S. Department of Energy
Economic Regulatory Agency Region VIII
1075 South Yukon Street
Lakewood, Colorado 80226
(303) 234-2420

ABSTRACT

A major fuel-burning installation (MFBI) is defined in 303.2 to include any boiler, burner, or other combustion or any combination of the above at a single site that burns fossil fuels. It does not include power plants, which are units that sell electricity. The regulations apply to any person owning, leasing, operating or controlling an MFBI.

Any MFBI that will be firing at a rate of 100 million Btu/hr or greater must file FEA Form C-607-S-O (MFBI-Early Planning Process Identification Report). This includes an MFBI that has two or more units with 50 million Btu/hr at the same location.

SCHEDULING MILESTONES Schedules A1 and A2 under form FEA-C-607-S-O are required to be filed on or before the 15th day of the month following the month that a preliminary study for the MFBI is completed. If there is no preliminary study, the form must be filed following the earliest of: (1) the formation of a contract for design of an MFBI, (2) the decision to initiate design work, or (3) the approval of construction funds.

PERMIT APPLICATION LEAD TIME

90 days.

OIL SHALE PERMIT

PERMIT TITLE

Rights of Way Across Public Lands

JURISDICTION

Federal

LEGAL CITATION

30 USC 186 and 43 USC 1761-1771; See also 43 CFR 2800

RESPONSIBLE AGENCY/CONTACT

U.S. Dept. of Interior
U.S. Bureau of Land Management
Colorado State Office
1600 Broadway, Room 700
Denver, Colorado 80202
(303) 837-4481

ABSTRACT

The Secretary, with respect to the public lands, and the Secretary of Agriculture, with respect to lands within the Naitonal Forest System (except in each case of land designated as wilderness), are authorized to grant, issue, or renew rights-of-way over, upon, under, or through such lands for--

(1) reservoirs, canals, pipelines, and other facilities and systems for the impoundment, storage, transportation, or distribution of water;

(2) pipelines and other systems for the transportation or distribution of liquids and gases other than water and other than oil, natural gas, synthetic liquid or gaseous fuels, or any refined product produced therefrom, and for storage of such materials in connection therewith;

(3) pipelines, slurry and emulsion systems, and conveyor belts for transportation and distribution of solid materials, and facilities for the storage of such materials in connection therewith;

(4) systems for generation, transmissions, and distribution of electric energy, except that the applicant shall also comply with all applicable requirements of the Federal Power Commission under the Federal Power Act of 1935 (49 Stat. 847; 16 U.S.C. 791);

(5) systems for transmission or reception of radio, television, telephone, telegraph, and other electronic signals, and other means of communication;

(6) roads, trails, highways, railroads, canals, tunnels, tramways, airways, livestock driveways, or other means of transportation, except where such facilities are constructed and maintained in connection with commercial recreation facilities on lands in the National Forest System; or

(7) such other necessary transportation or other systems or facilities that are in the public interest and that require rights-of-way over, upon, under, or through

(cont)

SCHEDULING MILESTONES

PERMIT APPLICATION LEAD TIME

OIL SHALE PERMIT

PERMIT TITLE

Rights of Way Across Public Lands (cont)

JURISDICTION

LEGAL CITATION

RESPONSIBLE AGENCY/CONTACT

ABSTRACT such lands.

Any temporary use of public lands that is related to a right of way, such as construction of a temporary road, is authorized through issuance of a Temporary Use Permit. Forms and Procedures are available in most BLM Offices.

A right-of-way application consists of four elements:

1) A written request, general in nature, describing the type of right-of-way sought, its proposed location (township, range, etc.), and dimensions. No specific format is required. (see 43 CFR 2802. 1-1)

2) Evidence of applicants qualifications (see 43 CFR 2802.1-4(a)).

3) Survey maps as required by 43 CFR 2802.1-5 (a).

4) Right-of-way fees as designated in 43 CFR 2802.12.

In addition, special land use permits for activities not mentioned may be applied for by written application.

SCHEDULING MILESTONES

Scheduling is dependent on complexity of project and should be discussed with the local BLM district office manager.

PERMIT APPLICATION LEAD TIME

Depends on project.

OIL SHALE PERMIT

PERMIT TITLE

Scientific, Pre-Historic, Historic and Archeological

JURISDICTION

Federal

LEGAL CITATION

Archeological and Historic Data Conservation Act of 1974

RESPONSIBLE AGENCY/CONTACT

U.S. Dept. of Interior
Bureau of Land Management
Colorado State Office
1600 Broadway
Denver, Colorado 80203
(303) 837-4481

ABSTRACT

The Secretary of Interior must be notified whenever a Federal or Federally assisted or licensed project could cause irreparable harm to areas of significant, pre-historic, historic, or archeologic value. Before any agency decision concerning an action, the State historic agency official must identify the properties within the confines of the impacted area that are included in or eligible for inclusion in the National Register.

The agency official must consult with the State Historic Preservation Officer in order to apply the National Register criteria to the evaluation of the proposed study area. Should disagreement exist after this step has been taken, the Secretary of the Interior's opinion is conclusive. It is the responsibility of the agency official to seek this opinion by written request.

SCHEDULING MILESTONES

Dependent of project. A survey will be conducted before disturbing the site. If impacts cannot be mitigated, the project may be stopped.

PERMIT APPLICATION LEAD TIME

Depends on project.

OIL SHALE PERMIT

PERMIT TITLE

Sundry Notices and Reports on Wells

JURISDICTION

Federal

LEGAL CITATION

RESPONSIBLE AGENCY/CONTACT

U.S. Dept. of Interior
Geological Survey
Area Oil Shale Supervisor
131 N. 6th Street, Suite 300
Grand Junction, Colorado 81501
(303) 245-6700

ABSTRACT

Every change of work on a well is required to be reported to the Geological Survey. These changes include intentions to drill, re-drill, repair a well, abandon well, test water, shoot or acidize, pull or alter a casing. Each change for each well requires the filing of a separate form. Form asks for Well number, loction, elevation, and description of work.

SCHEDULING MILESTONES

File a report or notice of intention only.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Oil Shale Mineral Rights Lease

JURISDICTION

Federal

LEGAL CITATION

30 U.S.C. 181-263; 43 CFR

RESPONSIBLE AGENCY/CONTACT

Peter A. Rutledge
U.S. Dept. of Interior
Area Oil Shale Supervisor
131 N. 6th Street, Suite 300
Grand Junction, Colorado 81501
(303) 245-6700

ABSTRACT

Under the terms and conditions of this lease, the lessee is granted the right to prospect for, mine, process by retorting or by in situ methods, or otherwise utilize and dispose of all leased deposits. In addition, the lessee has the right to construct buildings, structures, roads, powerlines, and additional facilities that may be necessary or convenient for mining, processing, or preparation of products of the leased deposits for market, and for the housing and welfare of employees, agents, and contractors. The lease is for a minimum period of 20 years and may continue as long as production continues. Terms of the lease are also subject to bonuses, royalties, rentals, and payments, as detailed in the regulations, all State and local water pollution control, water quality, air pollution control, and air quality laws, regulations, and Standards.

SCHEDULING MILESTONES

Before any development operations under the lease, the lessee is required to conduct a 2-year baseline monitoring and data collection program and a detailed development plan.

PERMIT APPLICATION LEAD TIME

Depends on project.

OIL SHALE PERMIT

PERMIT TITLE

Detailed Development Plan

JURISDICTION

Federal

LEGAL CITATION

30 CFR 231, 43 CFR 23, 43 CFR

RESPONSIBLE AGENCY/CONTACT

Peter A. Rutledge
U.S. Dept. of Interior
Geological Survey
Area Oil Shale Supervisor
131 N. 6th Street, Suite 300
Grand Junction, Colorado 81501
(303) 245-6700

ABSTRACT

Under Section 10 of the Oil Shale Lease, the lessee must file with the Mining Supervisor on or before the third anniversary date a detailed development plan (DDP). This plan includes: (1) a schedule of the planning, exploratory, development, production, processing, and reclamation operations and all other activities to be conducted under the lease; (2) a detailed description pursuant to 30 CFR 231 and 43 CFR 23 of the procedures to be followed to assure that the development plan will meet and conform to the environmental criteria and controls incorporated in the lease; and (3) a requirement that the lessee use orderly development to attain at the earliest time consistent with compliance of all provisions of the oil shale lease, production at a rate at least equal to the rate on which minimum royalty is completed under terms of the lease.

SCHEDULING MILESTONES

Requires a 2-year baseline monitoring and data collection program.

PERMIT APPLICATION LEAD TIME

Must be filed within 3 years of lease date.

OIL SHALE PERMIT

PERMIT TITLE

Collection of Environmental Data and Monitoring Program

JURISDICTION

Federal

LEGAL CITATION

30 CFR 231, 43 CFR

RESPONSIBLE AGENCY/CONTACT

Peter A. Rutledge
U.S. Dept. of Interior
Geological Survey
Area Oil Shale Supervisor
131 N. 6th Street, Suite 300
Grand Junction, Colorado 81501
(303) 245-6700

ABSTRACT

Under the environmental stipulations of the oil shale lease, completion of a 2-year baseline monitoring and data collection program is required, one year before the detailed development plan is submitted to the Mining Supervisor. The lessee is required to compile data to determine the conditions existing before any development operations under the lease and conduct a monitoring program before, during, and subsequent to development operations.

SCHEDULING MILESTONES

This 2-year program before release of the detailed development plan requires monitoring before any operations are permitted.

PERMIT APPLICATION LEAD TIME

2 years.

OIL SHALE PERMIT

PERMIT TITLE Exploration and Mining Plans	**JURISDICTION** Federal

LEGAL CITATION

30 CFR 231, 43 CFR 23

RESPONSIBLE AGENCY/CONTACT

Peter A. Rugledge
U.S. Dept. of Interior
Geological Survey
Area Oil Shale Supervisor
131 N. 6th Street, Suite 300
Grand Junction, Colorado 81501
(303) 245-6700

ABSTRACT

Under terms of the oil shale lease, any exploration and/or mining must have must have approval before any disturbance to the land occurs. The plan is a detailed report describing every aspect from sampling and drilling to reclamation, including any baseline monitoring. This is usually prepared in conjunction with the detailed development plan.

SCHEDULING MILESTONES

Prepared with detailed development plan.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE Mine Safety and Health—definition and control

JURISDICTION Federal

LEGAL CITATION

Federal Mine Safety and Health Amendments Act of 1977 P.L. 95-164

RESPONSIBLE AGENCY/CONTACT

U.S. Dept. of Labor
Mine Safety and Health Administration
Region VIII
Denver Federal Center
Lakewood, Colorado 80225
(303) 234-4378

ABSTRACT

Each operator of a mine is now required to have a mandatory health and safety training program approved by the Secretary of Labor. Some of the requirements include: (1) new miners must have no fewer than 40 hrs of training if they are to work underground. Training includes use of the self-rescue device and respiratory devices, procedures, instruction on basic ventilation, basic roof control, electrical hazards, first aid, etc.; (2) all miners must have at least 8 hrs of refresher courses once each year; and (3) special training must be provided for miners having no previous experience in a specific area.

Upon completion of each training program, each operator is to complete a form stating that the miner has received the training. A certificate for each miner is to be maintained by the operator and is to be available for inspection at the mine site, with a copy given to each miner.

SCHEDULING MILESTONES

None.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Notice of Intent to Prospect

JURISDICTION

Colorado

LEGAL CITATION

Colorado Mined Land Reclamation Act CRS 1973, 34-32-101 et seq.

RESPONSIBLE AGENCY/CONTACT

Director
Colorado Dept. of Natural Resources
Colorado Mined Land Reclamation Board
1313 Sherman Street, Room 718
Denver, Colorado 80202
(303) 839-3311

ABSTRACT

Any person desiring to prospect is required to file a Notice of Intent to Conduct Prospecting Operations on a form provided by the Board. Regulations required under such notice include:

1. Confinement of operations near roads or trails;
2. Plugging or capping of drill holes;
3. Reclamation of affected lands;
4. Dispersing or burying materials removed from a hole;
5. Backfilling and revegetating any pits; and,
6. Sealing, where necessary, aquifers to prevent intermingling of water.

Specific rules on reclamation are found under Rule 6, CRS 1973, 34-32-101.

SCHEDULING MILESTONES

Upon filing, the applicant shall post surety not to exceed $2000/acre to be disturbed. Upon completion is required to be filed. Whithin 90 days, the Mined Land Reclamation Board shall notify the applicant of steps to be taken for reclamation. Within 30 days after completion of reclamation, the board is to inspect the land. If the reclamation is found to be satisfactory, the Board will release the surety.

PERMIT APPLICATION LEAD TIME

Board treatment is on a case-by-case basis. No specific lead time is given.

OIL SHALE PERMIT

PERMIT TITLE

Permits for Special Operators

JURISDICTION

Colorado

LEGAL CITATION

Colorado Mined Land Reclamation Act, 1976 CRS 1973, 34-32-101, et seq.

RESPONSIBLE AGENCY/CONTACT

Harris Sherman
Colorado Dept. of Natural Resources
Colorado Mined Land Reclamation Board
1313 Sherman Street, Room 718
Denver, Colorado 80202
(303) 839-3311

ABSTRACT

Application for a special permit is required for any sand, gravel, or quarry aggregate operation that is to be operated for the sole purpose of obtaining materials for road, highway, utility, or similar-type construction under a Federal, State, county, city, town, or special district contract where the contract calls for work to be commenced within a specifically short time and which will affect 10 acres or less.

The application shall contain owners of surface and subsurface lands; conformance to existing zoning; map; legal description; identification of mining operation; reclamation costs; description of wildlife, plan. An application fee of $200 plus $15/acre is required.

SCHEDULING MILESTONES

Upon filing, the Mined Land Reclamation Board will set the time, date, and place for consideration of the application. Public notice and newspaper distribution is required. Protests are due by 4:00 p.m. the day before the Board hearing.

PERMIT APPLICATION LEAD TIME

At least 10 days between application filing and Board hearing.

OIL SHALE PERMIT

PERMIT TITLE

Permit for Limited Impact Operations

JURISDICTION

Colorado

LEGAL CITATION

Colorado Mined Land Reclamation Act, 1976 CRS 1973, 34-32-101 et seq.

RESPONSIBLE AGENCY/CONTACT

Harris Sherman
Colorado Dept. of Natural Resources
Colorado Mined Land Reclamation Board
1313 Sherman Street, Room 718
Denver, Colorado 80202
(303) 839-3311

ABSTRACT

Application for a limited impact permit is required for a mining operation affecting less than 10 acres for the life of the mine and extracting less than 70,000 tons of mineral, overburden, or combination thereof per calendar year. The application does not require any exhibits, but it does require information such as ownership of surface and subsurface rights, maps, legal descriptions, identification of mining operation, reclamation plan and costs, and information on wildlife, water resources, vegetation, soils, etc. A small application fee based on acreage is required.

On each anniversary date, the operator must file a notice of intent to continue mining, an annual fee of $50, statement of work accomplished over the preceding year, and land to be affected for the coming year.

SCHEDULING MILESTONES

Upon filing the application, the operator must place a copy of the application in public review, publish a notice in the newspaper for general circulation for 2 weeks, and notify land owners. The Board will give notice of time, date, and place for consideration within 30 days after filing. Objections must be filed within 5 days of the last date of publication of public notice or 48 hrs before consideration by the Mined Land Reclamation Board. A public hearing may be held if the Board determines protests to be valid.

PERMIT APPLICATION LEAD TIME

At least 30 days between filing of application and Board hearing.

OIL SHALE PERMIT

PERMIT TITLE Permit for Regular Mining Operations	**JURISDICTION** Colorado

LEGAL CITATION

Colorado Mined Land Reclamation Act, 1976 CRS 1973, 34-32-101 et. seq.

RESPONSIBLE AGENCY/CONTACT

Harris Sherman
Colorado Dept. of Natural Resources
Colorado Mined Land Reclamation Board
1313 Sherman Street, Room 718
Denver, Colorado 80202
(303) 839-3311

ABSTRACT Application for a permit for any mining operation affecting 10 acres or more, or extracting 70,000 tons or more of mineral overburden, or combination thereof per calendar year. Exhibits required under permit application include: Legal description, index map showing regional location, pre-mining and mining plan maps of affected land (surface area) and owner(s) of substance to be mined. An application fee is required that shall not exceed $2000.

On the anniversary date of each permit year, the operator is required to submit a report and map indicating the phases of the reclamation plan completed. In addition, an annual fee of from $275 to $350 is required.

SCHEDULING MILESTONES Upon filing of the application, a copy is to be provided for public review. Notices must be published in a newspaper for circulation for 4 weeks, and copies mailed to owners of surface rights. Proof of mailing and newspaper publication is required. Upon filing, the Mined Land Reclamation Board will set the date, time, and place for review of the application. This must be done within 90 days of the filing. If objections are raised, the board may elect to conduct a public hearing to consider protests. Objections must be raised within 20 days of the last published public notice.

PERMIT APPLICATION LEAD TIME At least 90 days after filing application (until Board meets for approval). Several months may be needed to complete the requirements of the application.

OIL SHALE PERMIT

PERMIT TITLE

Storage of Flammable Liquids

JURISDICTION

Colorado

LEGAL CITATION

CRS 1963, S7-4-18

RESPONSIBLE AGENCY/CONTACT

Director
Colorado Dept. of Natural Resources
Colorado Division of Mines
1313 Sherman Street, Room 719
Denver, Colorado 80203
(303) 839-3401

ABSTRACT

Storage of flammable liquids underground in excess of 55 gal requires a special permit from the Commissioner of Mines.

SCHEDULING MILESTONES

Subject to approval, review, and inspection by District Inspector.

PERMIT APPLICATION LEAD TIME

2 to 4 weeks.

OIL SHALE PERMIT

PERMIT TITLE

Application for Diesel Permit—Underground Operations

JURISDICTION

Colorado

LEGAL CITATION

CRS 1963, 57-11-53

RESPONSIBLE AGENCY/CONTACT

Director
Colorado Dept. of Natural Resources
Colorado Division of Mines
1313 Sherman Street, Room 719
Denver, Colorado 80203
(303) 839-3401

ABSTRACT

Any operation of diesel-powered equipment used underground in all metal mines, reclamation tunnels, clay mines, tunnel projects, or any underground mining operation (except coal mines) is required to have approval of the Division of Mines. Permit must be secured from the Division before equipment is taken underground.

SCHEDULING MILESTONES

A 10-day verbal temporary permit may be granted from the District Mining Inspector during the time a formal application is pending. Application approval is subject to review and possible inspection by the District Inspector.

PERMIT APPLICATION LEAD TIME

2 to 4 weeks.

OIL SHALE PERMIT

PERMIT TITLE Operator's Notice of Activity	**JURISDICTION** Colorado

LEGAL CITATION

CRS 1973, 34-47-123

RESPONSIBLE AGENCY/CONTACT

Director
Colorado Dept. of Natural Resources
Colorado Division of Mines
1313 Sherman Street, Room 719
Denver, Colorado 80203
(303) 892-3401

ABSTRACT

An operator or owner is required to notify the Division of Mines when work is commenced or stopped at any of the following operations: mine, mill, placer, quarry, open pit mine, dam project, tunnel project, or any public or quasi-public excavation.

SCHEDULING MILESTONES

Requirements are the mailing of the form only.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE Hoistman Certificate	**JURISDICTION** Colorado

LEGAL CITATION

CRS 1973, 34-47-123

RESPONSIBLE AGENCY/CONTACT

Director
Colorado Dept. of Natural Resources
Colorado Division of Mines
1313 Sherman Street, Room 719
Denver, Colorado 80203
(303) 892-3401

ABSTRACT

Every employer is required to have a competent employee who is a qualified hoisting engineer or hoistman to be on duty continuously at any manually controlled hoist where men are working above or below. Before being allowed to operate a hoist on which two or more employees are to be handled daily, the hoistman must be examined by a responsible doctor and must secure a certificate of health as prescribed by the Bureau of Mines. All hoistmen are required to be familiar with hoisting engines, must be able to read and write English, and must be between 18 and 65 years of age. A yearly examination and certificate renewal is required.

SCHEDULING MILESTONES

Subject to physical examination and approval of examining doctor. There is current debate on whether the Division of Mines or Division of Labor should have authority over this certificate.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Application to Store, Transport and Use Explosives

JURISDICTION

Colorado

LEGAL CITATION

CRS 1973, 34-27-101; 34-47-103; 9-7

RESPONSIBLE AGENCY/CONTACT

Norman Blake, Director
Colorado Dept. of Natural Resources
Colorado Division of Mines
1313 Sherman Street, Room 719
Denver, Colorado 80203
(303) 892-3401

ABSTRACT

Any operator intending to use, store, or transport explosives for either surface or underground operations is required to fill out an application. Applications require such information as location of mine, location in mine of explosives, kind and amount of exlosives, distances from other explosives, number of employees using explosives, magazine construction, and a sketch of the facility. A separate form is required for each type of explosive used.

SCHEDULING MILESTONES

Application is subject to review and approval by the District Inspector, who may elect to inspect facilities. Applicant should seek advice from the Colorado Mined Land Reclamation Board, who determines whether or not this application is necessary. There is current debate over whether the Division of Mines or Division of Labor should have authority over this application.

PERMIT APPLICATION LEAD TIME

Two weeks for review and approval.

OIL SHALE PERMIT

PERMIT TITLE

Reservoir Construction

JURISDICTION

Colorado

LEGAL CITATION

CRS 148-5-5 through 148-5-7

RESPONSIBLE AGENCY/CONTACT

State Engineer, Clarence Kuiper
Dept. of Natural Resources
Division of Water Resources
1313 Sherman Street, Room 818
Denver, Colorado 80202
(303) 839-3581

ABSTRACT

Any reservoir that has a capacity of more than 1,000 acre-ft or that has a dam or embankment in excess of 10 ft in vertical height, or that has a surface area at a high water line in excess of 20 acres requires approval of the State Engineer before construction. The owners of these reservoirs are required to pay the State Engineer the actual expenses he incurs in making a personal inspection and those incurred by any deputy assistants hired for supervision. The State Engineer shall also determine the amount of water that is safe to impound. All plans and specifications to be submitted must be approved by a registered professional engineer. These requirements are detailed in CRS 148-5-5 through 148-5-7.

SCHEDULING MILESTONES

Proper plans and specifications are to be submitted to the State Engineer.

PERMIT APPLICATION LEAD TIME

Depends on project.

OIL SHALE PERMIT

PERMIT TITLE

Water Well and Pump Installation (requirements)

JURISDICTION

Colorado

LEGAL CITATION

CRS 1963 148-20-4(1)(d) and 148-20-10(2)

RESPONSIBLE AGENCY/CONTACT

Clarence Kuiper
Colorado Dept. of Natural Resources
Division of Water Resources
1313 Sherman Street, Room 818
Denver, Colorado 80202
(303) 839-3581

ABSTRACT

Rules under this Colorado code provide minimum standards for location, construction, modification, or abandonment of water wells and installation, modification or repair of pumping equipment. A permit shall be obtained from the Office of the State Engineer before construction, deepening, enlarging, or increasing the yield of a water well and before initial pump installation or installation of a pump with a yield in excess of the registered yield of that well.

Work is to be performed only by or under supervision of a person having a valid license issued by the State Board of Examiners of Water Well and Pump Installation Contractors unless exempt under provisions of Section 148-20-6(3), CRS 1963, as amended.

Other specific requirements under these regulations apply to pollution sources. Permeability, horizontal and vertical distances from contaminants, draw-down characteristics, and other conditions of the aquifer must be considered. Municipal or county governments must be consulted when locating a well.

SCHEDULING MILESTONES Specific requirements must be met before approval. On permits to use groundwater and to construct a well, if within 6 months requirements do not meet the approval of the Division of Water Resources, the permit will be automatically rejected.

PERMIT APPLICATION LEAD TIME

Six months, maximum.

OIL SHALE PERMIT

PERMIT TITLE

Air Contaminant Emission Notices

JURISDICTION

Colorado

LEGAL CITATION Air Quality Control and Ambient Air Quality Standards, Colorado Air Pollution Control Act; CRS 1973, 25-7-102 et seq. Regulation 3.

RESPONSIBLE AGENCY/CONTACT

Executive Director
Colorado Dept. of Health
Colorado Air Pollution Control Division
1420 E. 11th Avenue
Denver, Colorado 80220
(303) 320-8333

ABSTRACT

No person shall permit emission of air contaminants from, or construction or alteration of, any facility, process, or activity from which air contaminants are or are to be emitted unless and until an Air Contaminant Emission Notice has been filed with the Air Pollution Control Division with respect to such emission. (Exceptions are outlined in Regulation No. 3, Section II.E.) A revised emission notice is required any time any change in emissions is anticipated or shall have occurred.

Each notice shall specify the following: the location at which the proposed emission will occur; the name and address of the person operating or owning such facility, process, or activity; and an estimate of the quantity and composition of the expected emission. The Division has available at all pollution control authority offices appropriate forms on which this information should be furnished.

A filing fee of $40 shall accompany each Air Contaminent Emission Notice.

SCHEDULING MILESTONES

Filing of forms and payment of fee required.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Land Use Special Permit

JURISDICTION

Colorado

LEGAL CITATION

RESPONSIBLE AGENCY/CONTACT

Colorado Department of Natural Resources
Division of Wildlife
6060 North Broadway
Denver, Colorado 80216
(303) 825-1192

ABSTRACT

A Land Use Special Permit may be required if monitoring work is done on Division of Wildlife lands.

SCHEDULING MILESTONES

Contact Department for specific requirements.

PERMIT APPLICATION LEAD TIME

Depends on project.

OIL SHALE PERMIT

PERMIT TITLE

Air Contaminant Emission Permit

JURISDICTION

Colorado

LEGAL CITATION Air Quality Control and Ambient Air Quality Standards Colorado Air Pollution Control Act; CRS 1973, 25-7-102 et. seq. Regulation 3.

RESPONSIBLE AGENCY/CONTACT

Executive Director
Colorado Dept. of Health
Colorado Air Pollution Control Division
4210 E. 11th Avenue
Denver, Colorado 80220
(303) 320-8333

ABSTRACT No construction or operation of any new direct air contamination source or substantial alteration of an existing air contamination source will be allowed without first obtaining or having a valid emission permit from the Division. (Exemptions are listed under Regulation No. 3, Section II.E.)

Applications for an emission permit will generally include (1) equipment information, and (2) plans, descriptions, and plans and drawings to provide engineering evaluations to determine whether appropriate air pollution control regulations, ordinance, and ambient air quality standards will be met. The Division may determine that it be necessary for the application to include acceptable ambient air monitoring and meteorological data, modeling results, and other evaluative techniques, procedures, and information sufficient in scope to determine if applicable ambient air quality standards will be met.

A filing fee of $40 is charged. The actual emission permit fee for a direct source is assessed at the time the Division issues final approval. The fee is calculated by a fee schedule based on the number of hours the Division spends in processing the permit, not to exceed $15,000 for all emission permits required for a contiguous plant site.

SCHEDULING MILESTONES Within 20 days of filing, the Division will make public its comments. Applications subject to public comment are limited to those stationary direct sources that show annual emissions exceeding 25 tons. Notices for public comment are limited to those stationary direct sources that show annual emissions exceeding 25 tons. Notices for public comment are made within 15 days after comment by the Air Pollution Control Division. Thirty days are then allowed for receipt of public comment. Within 15 days after preparation of its preliminary analysis where no delay for public comment is required, or within 30 days following the period for public comment, the Division will grant or deny the permit.

PERMIT APPLICATION LEAD TIME

Allow 90 days for application review and processing.

OIL SHALE PERMIT

PERMIT TITLE

Fugitive Dust Permit

JURISDICTION

Colorado

LEGAL CITATION Air Quality Control and Ambient Air Quality Standards Colorado Air Pollution Control Act; CRS 1973, 25-7-102 et seq. Regulation 3.

RESPONSIBLE AGENCY/CONTACT

Executive Director
Colorado Department of Health
Colorado Air Pollution Control Division
4210 E. 11th Avenue
Denver, Colorado 80220
(303) 320-8333

ABSTRACT

See Air Contaminant Emission Permit, under which fugitive dust is covered. In addition to the filing fee for a direct source, a $25 fee for processing a Fugitive Dust Permit is required.

SCHEDULING MILESTONES

See Air Contaminant Emission Permit.

PERMIT APPLICATION LEAD TIME

90 days.

OIL SHALE PERMIT

PERMIT TITLE

Open Burning Permit

JURISDICTION

Colorado

LEGAL CITATION

1973 CRS, 25-7-120

RESPONSIBLE AGENCY/CONTACT

Scott Miller
Colorado Department of Health
Air Pollution Control Division
125 N. 8th Street
Grand Junction, Colorado 81501
(303) 245-2400

ABSTRACT

Open burning is prohibited throughout the State unless a permit has been granted.

In granting or denying a permit, the authority shall base its action on the potential contribution to air pollution in the area, climatic conditions on the day or days of burning, and the authority's satisfaction that there is no practical alternative method for the disposal of the material to be burned.

Before a burn, notification must be given to the local fire control agencies. Burns are allowed between 10 a.m. and sunset. If there are any complaints of pollution from anyone in the area, the local fire agencies will require that the burn be immediately extinguished.

SCHEDULING MILESTONES

The form is available from the Air Pollution Control Division and is usually approved in a few weeks. Permit are renewed on an annual basis.

PERMIT APPLICATION LEAD TIME

30 days.

OIL SHALE PERMIT

PERMIT TITLE

Subsurface Disposal Permit

JURISDICTION

Colorado

LEGAL CITATION

CRS 1963, 66-28-400

RESPONSIBLE AGENCY/CONTACT

Colorado Department of Health
Water Quality Control Division
4210 E. 11th Avenue
Denver, Colorado 80220
(303) 320-8333

ABSTRACT

Any person proposing to construct or operate a subsurface disposal system is required to obtain a permit. The Division will issue a permit pursuant to public hearings (1) if no waters of the State will be polluted, or (2) if the pollution will be limited to waters in a specified limited area from which there is no risk of significant migration, and (3) if the proposed activity is justified by public need.

SCHEDULING MILESTONES

Public notice and public hearings are required for all surface and mineral owners of record within a 2-mile radius of any subsurface disposal system to voice complaints.

PERMIT APPLICATION LEAD TIME

Allow 3 months.

OIL SHALE PERMIT

PERMIT TITLE

Discharge Permit

JURISDICTION

Colorado

LEGAL CITATION Sections 25-8-501 through 508 CRS 1973 in conformity with the Federal Water Pollution Control Act Amendments of 1972, the Clean Water Act of 1977, and regulations promulgated thereunder.

RESPONSIBLE AGENCY/CONTACT

Director
Colorado Department of Health
Water Quality Control Commission
4210 E. 11th Avenue
Denver, Colorado 80220
(303) 388-6111

ABSTRACT The permit applies to all operations discharging to waters of the State from a point source. Prohibitions of a discharge permit include, but are not limited to, the following:

1. No discharge is allowed that will violate State, regional, or local land use plans unless all requirements and conditions of applicable Federal and State statutes and regulations are met or will be met according to a schedule of compliance. Similarly, no discharge is permitted that by itself or in combination with other pollutants will result in pollution of the receiving waters in excess of standards, unless the permit contains effluent limitations and a schedule of compliance with water quality requirements.
2. No discharge of any radiological, chemical, or biological warfare agent or high level radioactive waste is permitted. Limits of radiological wastes that may be discharged are determined by State water quality standards.
3. No discharge from a point source that is in conflict with an established water quality management plan promulgated under Sections 201, 208, 209, and 303(e) of the Federal Water Pollution Control Act of 1972 and the Clean Water Act of 1977 is permitted unless the waste discharge permit contains limitations and a schedule of compliance approved by the Division.

Frequency of measuring, monitoring, and reporting is dependent on specific discharges.

SCHEDULING MILESTONES An applicant is to apply for a permit at least 180 days in advance of the date the discharge is to begin. In some cases, the Division may determine that a site visit or extra information is necessary. In such a case, the applicant has 60 days to reply. Reapplication for continuance of a permit is required 180 days before expiration of the permit.

PERMIT APPLICATION LEAD TIME

180 days.

OIL SHALE PERMIT

PERMIT TITLE

Waste Disposal Plant Operator Certificate

JURISDICTION

Colorado

LEGAL CITATION

1963 CRS. 36-23-3

RESPONSIBLE AGENCY/CONTACT

Colorado Department of Health
Water Quality Control Division
4210 E. 11th Avenue
Denver, Colorado 80220
(303) 320-8333

ABSTRACT

Any person desiring to operate a solid waste disposal site and facility within the unincorporated portion of any county shall make application to the board of county commissioners of the county in which such site and facility is or is proposed to be located for a certificate of designation. Such application shall contain such engineering, geological, hydrological, and operational data as may be required by the department by regulation. The application shall be referred to the department for review and for recommendation as to approval or disapproval, which shall be based on criteria established by the State Board of Health, the State Water Pollution Control Commission, and the Air Pollution Control Commission.

SCHEDULING MILESTONES

None.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Potable Water Supply and Safety Compliance

JURISDICTION

Colorado

LEGAL CITATION

1963 CRS 66-1-7

RESPONSIBLE AGENCY/CONTACT

Colorado Department of Health
Water Quality Control Division
4210 E. 11th Avenue
Denver, Colorado 80220
(303) 320-8333

ABSTRACT

The Colorado Department of Health has the authority to examine plans, specification, and other related data pertaining to the proposed construction of any and all publicly or privately owned community water facilities submitted for review of sanitary engineering features before construction of such facilities. Facilities are inspected and reports are submitted to the Department of Health and local health departments on a regular basis.

SCHEDULING MILESTONES

Forms are available from the Colorado Department of Health. Time of approval is dependent of size of facility, inspection, and additional requested data.

PERMIT APPLICATION LEAD TIME

Depends on project.

OIL SHALE PERMIT

PERMIT TITLE

Sewage Plant Site Approval and Plant Approval

JURISDICTION

Colorado

LEGAL CITATION

CRS 1973, 25-8-200-, 25-8-704

RESPONSIBLE AGENCY/CONTACT

Colorado Department of Health
Water Quality Control Division
4210 E. 11th Avenue
Denver, Colorado 80220
(303) 320-8333

ABSTRACT

No operation of sewage treatment facilities is allowed until site approval and discharge permits have been filed and reviewed. No person shall commence construction or expansion of any sewage treatment works intended to serve more than 20 persons until the previous requirements have been met. In determining the suitability of a site location for any sewage treatment works, the Division shall consider the long-range comprehensive planning for the area and the consolidation of sewage treatment works to avoid proliferation of small sewage treatment works.

SCHEDULING MILESTONES

Depends of project.

PERMIT APPLICATION LEAD TIME

Depends on project.

OIL SHALE PERMIT

PERMIT TITLE

Purchase, Transportation, and Storage of Explosives

JURISDICTION

Colorado

LEGAL CITATION

CRS 1963, 53-7-1 et. seq.

RESPONSIBLE AGENCY/CONTACT

Colorado Department of Labor
Industrial Commission
251 E. 12th Avenue, Room 304
Denver, Colorado 80203
(303) 839-2446

ABSTRACT

Permits must be obtained for manufacture, sale, storage, transport, or use of explosives or blasting agents in the interest of life, health, and safety of employees and the general public, and for the protection of property. Permits are issued under the classes of manufacture, sale, storage, transport, or use and are renewed at the beginning of the calendar year.

SCHEDULING MILESTONES

Application for a permit is made on Division of Labor forms. If a permit is desired, a hearing may be conducted, and an appeal may take place.

PERMIT APPLICATION LEAD TIME

Generally, 2 months.

OIL SHALE PERMIT

PERMIT TITLE

Oil Facility Inspection

JURISDICTION

Colorado

LEGAL CITATION

NFPA pamphlet No. 30 (National Fire Prevention Association)

RESPONSIBLE AGENCY/CONTACT

Colorado Department of Labor
Oil Facility Division
1313 Sherman Street
Denver, Colorado 80203
(303) 289-5643

ABSTRACT

Approval is necessary for gasoline storage in excess of 1,500 gal. A plot plan showing storage location in relation to buildings and roads, and size of tanks is required. Approval is immediate (1 to 2 weeks).

SCHEDULING MILESTONES

File plot plan.

PERMIT APPLICATION LEAD TIME

1 to 2 weeks.

OIL SHALE PERMIT

PERMIT TITLE

Boiler Inspection Permit

JURISDICTION

Colorado

LEGAL CITATION

RESPONSIBLE AGENCY/CONTACT

Colorado Department of Labor
Boiler Inspection Division
1313 Sherman Street
Denver, Colorado 80203
(303) 289-5641

ABSTRACT

All boilers in use require a permit. Permits are updated by inspection on an annual basis.

SCHEDULING MILESTONES

Arrange for an appointment for an inspection. If approved, operator or owner will be billed and mailed a certificate within 30 days.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Oil Shale Leases

JURISDICTION

Utah

LEGAL CITATION

UCA 65-1-111 through 65-1-114

RESPONSIBLE AGENCY/CONTACT

Utah Department of Natural Resources
Board and Division of State Lands
105 State Capitol
Salt Lake City, Utah 84114
(801) 533-5381

ABSTRACT

The State Land Board is authorized to participate with its oil shale lessees in programs for the development of technology for the economic recovery of fuel substances from oil shale. State law provides for the authorization of the Board and Division of State Land's participation in the development of oil shale technology by crediting against future annual oil shale lease rentals in excess of fifty cents per acre the costs of lessee-financed programs for development. (Laws 1969, ch. 220).

Application is made on forms provided by the Division. Most of the leases extend for a primary term of 20 years, and for as long afterward as oil shale, kerogen, or elements of oil shale are being produced in commercial quantities.

SCHEDULING MILESTONES

If an application is deficient, it will be returned to the applicant with instructions for its amendment or completion. Processing time is dependent on amount of land and plans for development.

PERMIT APPLICATION LEAD TIME

At least 4 months.

OIL SHALE PERMIT

PERMIT TITLE

Ground Water Well Application

JURISDICTION

Utah

LEGAL CITATION

Utah Administrative Rule Code A28-03-17 Part III UCA 73-3-25

RESPONSIBLE AGENCY/CONTACT

Utah Department of Natural Resources
State Engineer
Division of Water Rights
435 State Capitol
Salt Lake City, Utah 84114
(801) 533-6071

ABSTRACT

Specific plans should be submitted to the Division for approval. In the application, a detailed report should be submitted showing sites available, the existence of sink holes, caves, test holes, abandoned wells, borings, sewerage in area, other wells, other water supply sources, and geology. Unless previously submitted, a summary of the design including information relative to test well drilling, geophysical prospecting specific yield, and chemical analysis should be provided. Detailed plans should also be submitted. These include a plot of the site, sources of pollution, elevations, and a schematic drawing.

All drilling permits expire at the end of the calendar year. A bond of $500 is required under the regulations.

SCHEDULING MILESTONES

After application is received and reviewed by the State Engineer, public notice of application is given once a week for 3 weeks, after which, a 30-day period is given to recieve public protests. Any protests go to a hearing, after which a judgement may be made.

PERMIT APPLICATION LEAD TIME

If there are no protests, 4 months.

OIL SHALE PERMIT

PERMIT TITLE Application for Water Rights	**JURISDICTION** Utah

LEGAL CITATION

UCA: 73-3-1 et. seq.

RESPONSIBLE AGENCY/CONTACT

Director
Utah Department of Natural Resources
Division of Water Rights
231 E. 400 South, Room 200
Salt Lake City, Utah 84111
(801) 533-6071

ABSTRACT

Application for right to use unappropriated public water shall file application with the State Engineer. Blank forms are available and require the name and address of person, corporation, or association making application, the nature of proposed use, the quantity of water or flow to be appropriated, the time during which it is to be used every year, the name of stream or other source from which the water is to be diverted, and the nature of the diverting works.

The State Engineer may issue a temporary permit to drill a well at any time after filing of an application to appropriate water if fees are paid and if there is unappropriated water available, and if there is no likelihood of impairment of existing rights.

SCHEDULING MILESTONES

After application is received and reviewed by the State Engineer, public notice of application will be given once a week for 3 weeks. After the third notice, 30 days are to be allowed for written public protest, after which a public hearing may be held. After the public hearing, judgement will be made. A maximum fee of $150 is possible.

PERMIT APPLICATION LEAD TIME

If there are no protests, 4 months.

OIL SHALE PERMIT

PERMIT TITLE

Mined Land Reclamation

JURISDICTION

Utah

LEGAL CITATION

UCA 40-6-3 amended, Laws of Utah Chapter 176 H.B. No. 323 passed May 12, 1975.

RESPONSIBLE AGENCY/CONTACT

Utah Department of Natural Resources
Mined Land Reclamation
Division of Oil, Gas, and Mining
1588 West North Temple
Salt Lake City, Utah 84116
(801) 533-7771

ABSTRACT

Before commencement of mining operations, the operator shall file a notice of intent for each mining operation. The form of the notice shall be provided for in the rules and promulgated by the Division. The notice shall require the operator to detail a plan of reclamation of the lands affected. In connection with the notice, the operator shall furnish evidence in the form of acceptable insurance policies or other factual data that the operator will be financially responsible during the proposed mining operations for the payment of offsite public liability or property damage claims for which he may become liable.

SCHEDULING MILESTONES

Within 30 days of receipt of notice of intention, the Division of Oil, Gas, and Mining will complete its review and will make further inquiries, inspections, or examinations, as may be necessary. The operator will be notified of objections and given opportunity to respond. Within 30 days following the last action, the Division will make a tentative decision with respect to approval and will publish public notice. If no factual written protests are received within 30 days, final approval will be given.

PERMIT APPLICATION LEAD TIME

Barring objections from the Division or the public, 90 days.

OIL SHALE PERMIT

PERMIT TITLE

Permit for Exploration and Excavation

JURISDICTION

Utah

LEGAL CITATION

UCA 63-11-2 (1969)

RESPONSIBLE AGENCY/CONTACT

Utah Department of Natural Resources
Division of Parks and Recreation
1596 West North Temple
Salt Lake City, Utah 84116
(801) 533-6011

ABSTRACT

Before any exploration or excavation in or on any prehistoric ruins, pictographs, hieroglyphs, or any other ancient markings or writing or archaeological or paleontological deposit in Utah on any public lands, either State or Federal, shall be undertaken, a permit shall first be obtained from the division of parks and recreation. The board of parks and recreation is authorized to promulgate for division enforcement such regulations as it may deem needful to protect from vandalism or injury and prehistoric ruins and relics and archaeological and paleontological deposits of the State and also all natural bridges and natural scenic features and formations. No person shall remove from the State of Utah any part of any such ruins or deposit except with the consent of the Division of Parks and Recreation. As a condition to such consent, the Division may require that a portion of such relics, materials, or deposit remain the property of the State or of the county wherein such ruins or deposits are found. Any person violating this act or the rules and regulations promulgated by the Board of Parks and Recreation pursuant thereto shall be guilty of a misdemeanor and upon conviction thereof shall, in addition to any other penalties imposed, forfeit to the State all articles and materials discovered by or through his efforts.

SCHEDULING MILESTONES

Description of area, work to be done, and description of ruins or deposits on a detailed scale is submitted for evaluation. Notice is set for public protest, and public hearings may result based on protest.

PERMIT APPLICATION LEAD TIME

Depends on extent of work, area, and potential historic value.

OIL SHALE PERMIT

PERMIT TITLE

Open Burning

JURISDICTION

Utah

LEGAL CITATION

UCA 26-24, Air Conservation Regulations A 28-03-2b

RESPONSIBLE AGENCY/CONTACT

Utah Department of Social Services
Division of Environmental Health,
Bureau of Air Quality
72 East 4th South, Suite 305
Salt Lake City, Utah 84102
(801) 533-6108

ABSTRACT

When not prohibited by other laws or officials having jurisdictions and when a nuisance is not created, the following types of open burning are permissible following written application and appropriate hearing:

1) Open burning of solid or liquid fuels or structures for removal of hazards or eyesores,

2) Open burning in remote areas of highly explosive or other hazardous materials for which there is no other known practical method of disposal,

3) Open burning of tree cuttings and brush within right of ways or for other clearance,

4) Other special purposes or under unusual circumstances.

SCHEDULING MILESTONES

No time frame.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Fuel Burning—Sulfur Content Exemption

JURISDICTION

Utah

LEGAL CITATION

UCA 26-24 Air Conservation Regulations A-28-03-2d

RESPONSIBLE AGENCY/CONTACT

Utah Department of Social Services
Division of Environmental Health,
Bureau of Air Quality
72 East 4th South, Suite 305
Salt Lake City, Utah 84102
(801) 533-6108

ABSTRACT

Any person engaged in operating fuel-burning equipment using coal or fuel oil may apply for an exemption from the restrictions of no more than 1.0 percent sulfur by weight or 1.5 percent sulfur by weight for coal and fuel oil, respectively. The application shall furnish evidence that the equipment is operating in such a manner as to prevent the emission of sulfur dioxide in excess of the limitations. Control apparatus to continuously prevent the emission of sulfur greater than provided by the limitations must be specified in the application for an exemption. Application is made with the Executive Secretary.

SCHEDULING MILESTONES

No time frame.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Permit to Construct Facilities that are Sources of Air Pollution

JURISDICTION

Utah

LEGAL CITATION

UCA 26-24-9, Air Conservation Act

RESPONSIBLE AGENCY/CONTACT

Utah Department of Social Services
Division of Environmental Health,
Bureau of Air Quality
72 East 4th South, Suite 305
Salt Lake City, Utah 84102
(801) 533-6108

ABSTRACT Notice must be given to the Executive Secretary by any person planning to construct a new installation or modify an existing installation that may be a direct or indirect source of air pollution. This also includes any person planning to install an air-cleaning device or other equipment intended to control emission of air contaminants. The Executive Secretary may require, as a condition precedent to the construction, installation, or establishment of the air contaminant source, the submission of plans, specifications, and other such information as he deems necessary to determine whether the proposed construction, installation, or establishment will be in accord with applicable rules and regulations in force under this act.

Plan approval for an indirect source may be delegated by the Executive Secretary to a local authority when requested and upon assurance that the local authority has and will maintain sufficient expertise to ensure that the planned installation will meet the requirements established by law.

SCHEDULING MILESTONES If within 90 days after the receipt of plans, specifications, or other information required under this section, the executive secretary determines that the proposed construction, installation, establishment, or any part of it will not be in accord with the requirements of this act or the applicable rules and regulations, or that further time (not to exceed three extensions of 30 days each) is required by the committee to review adequately the plant, specifications, or other information, he shall issue an order prohibiting the construction, installation, or establishment of the air contaminant source or sources in whole or in part.

In addition to any other remedies available on account of the issuance of an order either granting or denying a request for the construction of a new installation, and before invoking any such remedies, any person or persons aggrieved by this shall, upon request, in accordance with the rules of the committee, be entitled to a hearing. Following the hearing, the permit may be affirmed, modified, or withdrawn.

PERMIT APPLICATION LEAD TIME

At least 90 days.

OIL SHALE PERMIT

PERMIT TITLE

Permit to Construct and Operate Treatment Works

JURISDICTION

Utah

LEGAL CITATION

UCA 73-14-5

RESPONSIBLE AGENCY/CONTACT

Utah Department of Social Services
Division of Environmental Health
Committee on Water Pollution
44 Medical Drive
Salt Lake City, Utah 84112
(801) 533-6111

ABSTRACT

It is unlawful for any person to carry on any of the following activities without first securing a permit from the Division, as is required, for the disposal of all wastes that are or may be discharged into the waters of the State: (1) The construction, installation, modification, or operation of any treatment works or part thereof or any extension or addition thereto; (2) the increase in volume or strength of any wastes in excess of the permissive discharges specified under any existing permit; (3) the construction, installation, or operation of any establishment or any extension or modification thereof or addition thereto, the operation of which would cause an increase in the discharge of wastes into the waters of the State or would otherwise alter the physical, chemical, or biological properties of any waters of the State in any manner not already lawfully authorized; (4) the construction or use of any new outlet for the discharge of any wastes into the waters of the State.

SCHEDULING MILESTONES

The Division of Environmental Health has no special forms. A report must be prepared by an engineer showing the design basis and construction plans. If all information is supplied when first submitted, processing takes about 1 month. If additional data are required, processing may take an additional 2 to 3 months.

PERMIT APPLICATION LEAD TIME

Approximately 3 months.

OIL SHALE PERMIT

PERMIT TITLE

Water Quality—Definition and Control

JURISDICTION

Utah

LEGAL CITATION

Standards for Water Quality A28-03-11 UCA 26-15-4 and 73-14-1 et seq. (1953) amended.

RESPONSIBLE AGENCY/CONTACT

Utah Department of Social Services
Division of Environmental Health
Committee on Water Pollution
44 Medical Drive
Salt Lake City, Utah 84112
(801) 533-6111

ABSTRACT

Waters whose existing quality is better than the established standards will be maintained at high quality unless it has been affirmatively demonstrated to the State that a change is justifiable as a result of necessary economic or social development and will not preclude present and anticipated use of such waters. Any industrial, public, or private project or development that would constitute a new source of controllable pollution or an increased source of controllable pollution to high quality waters will be required to provide waste treatment to maintain high quality water to the extent that such treatment is practicable. In implementing this policy, the Secretary of the Interior will be kept advised of and will be provided with such information as he will need to discharge his responsibilities under the Federal Water Pollution Control Act as amended.

SCHEDULING MILESTONES

None.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE	JURISDICTION
Permit to Operate Solid Waste Disposal Site	Utah

LEGAL CITATION

Code of Solid Waste Disposal Regulations A28-03-19 UCA 26-15-5 (1953) amended.

RESPONSIBLE AGENCY/CONTACT

Utah Department of Social Services
Division of Environmental Health
44 Medical Drive
Salt Lake City, Utah 84112
(801) 533-6111

ABSTRACT

It is unlawful for any person to deposit any solid waste in any place except at a site that has been designated by a city, county, district, or other properly designated agency, and approved by the Utah State Division of Health. This requirement does not include the deposition of inert construction debris used as fill material or mine tailings and overburden, provided such deposition does not cause a public nuisance or hazard or contribute to air or water pollution. Provisions are available for solid wastes.

Design plans and related information shall be submitted to the Division for review and approval before construction. Plans include: location, characteristics of area, type of waste, soil description, provisions of fire control, land ownership or lease agreement, etc., and any other information requested by the Division.

SCHEDULING MILESTONES

Approval is required before construction. Approval includes limitations on types of wastes to be accepted.

PERMIT APPLICATION LEAD TIME

90 days.

OIL SHALE PERMIT

PERMIT TITLE

Notice of Intention to Operate Or Suspend Operations

JURISDICTION

Utah

LEGAL CITATION

Nonmetal Federal Mandatory Standards with State codes. Administrative Rule A71-02-10 Sec. 5.

RESPONSIBLE AGENCY/CONTACT

Utah Industrial Commission and
Labor Relations Board
Division of Safety
350 East 5th South
Salt Lake City, Utah 84111
(801) 533-6411

ABSTRACT

The owner, operator, or person in charge of any metal or nonmetal mine shall notify the Industrial Commission of Utah, before starting operations, of the approximate or actual date of commencement of mine operations. The notification shall include mine name, location, company name, mailing address, person in charge, and whether operations will be continuous or intermittent.

When any mine is closed, the person in charge shall notify the Industrial Commission of Utah, as provided above, and indicate whether closure is temporary or permanent.

SCHEDULING MILESTONES

Filing of forms only.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Hoistman-Qualifications

JURISDICTION

Utah

LEGAL CITATION

Metal and Nonmetal Federal Mandatory Standards with State Codes. Administrative Rule A71-02-10 Sec. 66.

RESPONSIBLE AGENCY/CONTACT

Utah Industrial Commission and
Labor Relations Board
Division of Safety
350 East 5th South
Salt Lake City, Utah 84111
(801) 533-6411

ABSTRACT

Hoistmen and motormen who regularly transport men in shafts or along slopes, planes, raises or inclines, or along main haulage roads on the surface and underground, shall undergo physical examinations to determine their physical fitness before being assigned to such duties, and at least annually thereafter. A copy of the examining physician's report, on a form provided by the Industrial Commission, shall be returned to the mine superintendent or other authorized official who, if satisfied as to the general competency of such person to perform such duties, shall so certify on that copy and forward it to the Industrial Commission. The Commission, if satisfied as to the applicant's fitness to perform such duties, shall issue an appropriate certificate. Hoistmen certificates shall be posted in the hoist rooms, and motormen certificates in a suitable and conspicuous place in the mine. Certificates shall expire on the first day of January each year. Applications for certificate renewal shall be submitted to the Industrial Commission within 30 days preceding expiration date.

SCHEDULING MILESTONES

None.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Escape and Evacuation Plans

JURISDICTION

Utah

LEGAL CITATION

Utah Administrative Rules A71-02-1

RESPONSIBLE AGENCY/CONTACT

Utah State Industrial Commission and
Labor Relations Board
Division of Safety
448 South 4th East
Salt Lake City, Utah 84111
(801) 533-6411

ABSTRACT

A specific escape and evacuation plan suitable to the conditions and mining system of the mine and showing responsibilities of all key personnel in the event of an emergency shall be developed by the operator and set out in written form. Copies of the plan and revisions shall be available to the Division. Also, copies of the plan shall be posted at locations convenient to all persons on the surface and underground. The plan is to be updated and reviewed once every 6 months.

SCHEDULING MILESTONES

Preparation and updating of plans are only requirements.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Boiler and Pressure Vessel—definition and control

JURISDICTION

Utah

LEGAL CITATION

Utah Administrative Rules A71-02-5

RESPONSIBLE AGENCY/CONTACT

Utah State Industrial Commission and
Labor Relations Board
Division of Safety
448 South 4th East
Salt Lake City, Utah 84111
(801) 533-6411

ABSTRACT

All boilers and pressure vessels used where workman or the public may be exposed to risks shall be designed, constructed, inspected, stamped, and installed in accordance with the applicable ASME Boiler and Pressure Vessel Code Rules and Regulations.

In addition, boilers and pressure vessels shall be registered with the National Board and shall bear a registration number. A copy of the manufacturer's data report shall be filed with the Chief Inspector through the National Board before installation in the State of Utah.

If a boiler or pressure vessel is of special design or one that cannot bear ASME stamping, details of the proposed construction, including shop drawings, shall be admitted to the Chief Inspector, and approval as "State of Utah Special" for construction and installation must be obtained from the Commission before construction is started.

SCHEDULING MILESTONES

None.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Storage of Explosives

JURISDICTION

Utah

LEGAL CITATION

UCA 40-5-4

RESPONSIBLE AGENCY/CONTACT

Utah State Industrial Commission and
Labor Relations Board
Division of Safety
350 East 5th South
Salt Lake City, Utah 84111
(801) 533-6411

ABSTRACT

It is unlawful to have stored at any shaft house or within the underground workings of any mine at one time more than enough powder or other high explosive to do the work for each 24 hours without first having obtained written permission from the Industrial Commission. Any violation is punishable by fines of from $100 to $1000.

SCHEDULING MILESTONES

Written consent needed.

PERMIT APPLICATION LEAD TIME

1 to 2 weeks.

OIL SHALE PERMIT

PERMIT TITLE Construction of Wastewater Ponds and Holding Facilities	**JURISDICTION** Wyoming

LEGAL CITATION

WSA 35-502-18

RESPONSIBLE AGENCY/CONTACT

Wyoming Department of Environmental Quality
Division of Water Quality
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7781

ABSTRACT

Any construction, installation, or modification of an existing treatment works, disposal system, or holding facility capable of causing or contributing to pollution is to submit a written application on a form provided by the Division of Water Quality. All plans and specifications must carry the approval of a registered State Engineer.

The application includes all designs, specifications, plans, and other pertinent information covering the project as determined by the Administrator.

SCHEDULING MILESTONES

Applications must be submitted 60 days before construction. No construction may commence until a permit is issued. When the application is deemed complete, the review of the application will be completed within 45 days by the Administrator.

PERMIT APPLICATION LEAD TIME

4 to 6 months.

OIL SHALE PERMIT

PERMIT TITLE

Construction of Sewage Facility

JURISDICTION

Wyoming

LEGAL CITATION

WSA 35-502-18

RESPONSIBLE AGENCY/CONTACT

William Garland, Administrator
Wyoming Department of Environmental Quality
Division of Water Quality
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7781

ABSTRACT

Any construction, installation, or modification of an existing sewage facility requires the submission of a written application with the approval of a registered State Engineer. In some cases, small facilities may obtain from a local authority approval for construction within 10 days. The application must include all plans, specifications, and designs and other pertinent information as determined by the Administrator.

SCHEDULING MILESTONES

Applications are usually submitted 60 days before construction. No construction may commence until a permit is issued. When the application is deemed complete, the review will be completed within 45 days. In the case of a small facility, approval may be granted by a local authority in 10 days.

PERMIT APPLICATION LEAD TIME

4 months.

OIL SHALE PERMIT

PERMIT TITLE Subsurface Discharges	**JURISDICTION** Wyoming

LEGAL CITATION

WSA 35-11-101 through 1104

RESPONSIBLE AGENCY/CONTACT

William Garland, Administrator
Wyoming Department of Environmental Quality
Division of Water Quality
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7781

ABSTRACT

The purpose is to control groundwater pollution by establishing a permitting process for subsurface discharges through wells for underground waste management, artificial recharge, and special process discharges to prevent the endangerment of groundwaters of the State that are or have the potential for being beneficially used.

The administrator will review the application for completeness. The applicant may be contacted for submittal of additional information. Information includes, maps, geological data, type of discharge, dates of operation, plan of program, and others.

Permits may be issued on a well-by-well basis, or by project, field block, area or other appropriate method, providing wells covered by a single permit are all within a single, legally definable parcel of land and under control of one legal entity. Permits may be issued for up to a period of 5 years.

SCHEDULING MILESTONES

Within 60 days of receipt of a completed application, the administrator will make a tentative determination with respect to issuance or denial of a permit. If determined sufficient, a draft permit is made available for public inspection. A public hearing may be requested within 30 days. Once all requirements are satisfied, a permit will be issued.

PERMIT APPLICATION LEAD TIME

At least 90 to 120 days.

OIL SHALE PERMIT

PERMIT TITLE Mining Permit, Mining and Reclamation Plan	**JURISDICTION** Wyoming

LEGAL CITATION

WSA 35-11-405 and 406

RESPONSIBLE AGENCY/CONTACT

Walter Ackerman, Administrator
Wyoming Department of Environmental Quality
Land Quality Division
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7756

ABSTRACT

A mining permit is the certification that the tract of land described may be mined by an operator licensed to do so in conformance with an approved mining and reclamation plan. No mining operation is allowed to commence until a valid permit has been obtained.

Application includes a mining and reclamation plan dealing with the extent to which the mining operation will disturb, change, or deface the lands to be affected, the proposed future use or uses, and the plan whereby the operator will reclaim the affected lands to the proposed future use or uses. The mining and reclamation plan shall be consistent with the objectives and purposes of the Environmental Quality Act rules and regulations defined under WSA 35-11-406. In addition, the Administrator may deny an application in an area where prior scientific investigations affirm the existence of significant artifacts, fossil, or other articles of archeological or paleontological interest. Upon recommendation, the Administrator may require an evaluation of such area before issuance of the permit.

SCHEDULING MILESTONES

Applications are subject to 90-day State review for completeness; within 15 days following assurance of completeness, a 30-day notice for public comment is made. Interested parties then have 20 days to make complaints, and a decision will then be made within 30 days after completion of notice period.

PERMIT APPLICATION LEAD TIME

At least 6 months, if no complaints are voiced.

OIL SHALE PERMIT

PERMIT TITLE

Notification of Mining Operations (control)

JURISDICTION

Wyoming

LEGAL CITATION

WSA 30-2-214 through 3-2-317

RESPONSIBLE AGENCY/CONTACT

Walter Ackerman, Administrator
Wyoming Department of Environmental Quality
Land Quality Division
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7756

ABSTRACT

Notice must be given to the inspector of mines for abandonment or commencement of a mining operation, or change of ownership of mining property. Notice of abandonment must be given far enough in advance so that a final inspection may be made before it is closed down. Within 30 days after commencement of any mining operation, the owner or operator is required to notify the inspector of mines of the date and place of commencement.

SCHEDULING MILESTONES

Notice must be given 30 days before abandonment and 30 days after commencement of operations.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Discharges—In Situ Mining

JURISDICTION

Wyoming

LEGAL CITATION

WSA 35-11-101 through 425

RESPONSIBLE AGENCY/CONTACT

Administrators
Wyoming Department of Environmental Quality
Water Quality and Land Divisions
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7391

ABSTRACT

The purpose is to establish a permitting process to protect the surface waters and groundwaters of the State from pollution, to control the injection and recovery of fluids and pollutants into and from groundwaters, and to reclaim any land disturbance that may result from in situ mining activities.

The owner or operator of an in situ mining facility must apply for a permit. Application requirements include: a site facility description; soils, vegetation, and surface hydrology information; a waste control plan and program; geologic information; groundwater information; proposed hydrologic testing; and plans for monitoring, groundwater restoration, and land reclamation programs.

SCHEDULING MILESTONES

Application is submitted for review by the Administrator, who will notify applicant within 90 days if application is incomplete. Public inspection and public hearings are allowed for any protests. A period of 20 days is allowed for public protests. After all requirements are satisfied, a permit will be issued.

PERMIT APPLICATION LEAD TIME

At least 120 days.

OIL SHALE PERMIT

PERMIT TITLE Construction and Operating Permit for New or Modification to Existing Facility

JURISDICTION

Wyoming

LEGAL CITATION

Air Quality Standards and Regulations, Section 21

RESPONSIBLE AGENCY/CONTACT

Randolph Wood, Administrator
Wyoming Department of Environmental Quality
Air Quality Division
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7391

ABSTRACT

Application must be made by any person planning to construct a new installation or to modify an existing installation that may be a direct or indirect source of air pollution. This includes any installation of air cleaning devices to control emission of air contaminants. The permit is required before construction. Information required includes an impact analysis, potential emission rates, size of facility, location, etc.

Forms are available from the Air Quality Division with guidelines that pertain specifically to surface mining. The Division encourages prospective applicants to meet with them before filing.

After startup, a facility has 120 days to obtain an operating permit. During that time, the facility must show that it is in compliance with all air quality emission standards.

SCHEDULING MILESTONES

The Division has 30 days to review form for completeness, followed by a 60 day review. At that time, the Division will announce its decision in public notice and allow 30 days for public comment. Based on public comment, a final decision may or may not be made.

PERMIT APPLICATION LEAD TIME At least 120 days for a construction permit, followed by 120 days after startup for an operating permit.

OIL SHALE PERMIT

PERMIT TITLE

Open Burning Permit

JURISDICTION

Wyoming

LEGAL CITATION

Wyoming Environmental Quality Act, Sections 35-502, 10 et. seq. Section 13, Wyoming Quality Standards and Regulations, 1978

RESPONSIBLE AGENCY/CONTACT

Randolph Wood, Administrator
Wyoming Department of Environmental Quality
Air Quality Division
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7391

ABSTRACT

Open burning is prohibited throughout the State unless a permit is issued. In granting or denying a permit, the Air Quality Division shall base its action on the potential contribution to air pollution in the area, climatic conditions on the day or days of burning, and the authority's satisfaction that there is no practical alternative method for the disposal of the material to be burned. This last requirement is governed by very stringent rules, and very few permits are issued because of it.

Before any burn, if a permit is obtained, notification must be given to the local fire authorities, and requirements given by them must be met.

SCHEDULING MILESTONES

No specific form is available. Information is to be provided to the Air Quality Division in letter form. No specific time frame is given—application aproval depends on situation.

PERMIT APPLICATION LEAD TIME

Depends on project.

OIL SHALE PERMIT

PERMIT TITLE

Permit to Dispose of Hazardous Wastes

JURISDICTION

Wyoming

LEGAL CITATION

Wyoming Environmental Quality Act, Article 5, Section 35-502. 24 et. seq. Solid Waste Management Rules and Regulations, Section 11.

RESPONSIBLE AGENCY/CONTACT

Charles Porter, Administrator
Wyoming Department of Environmental
Quality
Solid Waste Division
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7752

ABSTRACT

If any hazardous wastes are to be disposed of in a mining operation, a permit must be obtained. Guidelines for specific information to be provided are found in the Wyoming Environmental Quality Act Rules and Regulations. Basically, the owner or operator must submit a plan of operation, including a map, plot plan, description of area, proposed dates of operation, types of waste, types of disposal, geologic conditions, groundwater and surface water conditions, etc.

SCHEDULING MILESTONES

No public hearings are involved, although EPA is proposing that States implement hearings into their regulations. After a 60-day review, if no additional information is necessary, a temporary permit will be issued. Construction of disposal facility may commence, and after completion, a final inspection and permit will be issued.

PERMIT APPLICATION LEAD TIME

60 days.

OIL SHALE PERMIT

PERMIT TITLE

Approval for Construction and Operation of Waste Facility

JURISDICTION

Wyoming

LEGAL CITATION

Wyoming Environmental Quality Act, Article 5, Section 35-502. 42 et. seq. Solid Waste Management Rules and Regulations, Section 11.

RESPONSIBLE AGENCY/CONTACT

Charles Porter, Administrator
Wyoming Department of Environmental Quality
Solid Waste Division
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7752

ABSTRACT

It is unlawful for any person to dispose of any industrial wastes without first obtaining a permit. Guidelines for specific information for filing an application can be found in the Solid Waste Management Rules and Regulations. Generally, a plan of operation is required for approval in obtaining a permit. The plan requires a map of the area, a plot plan, description of area and work, proposed dates of operation, types of waste, method of disposal, geologic, ground, and surface water characteristics, etc.

SCHEDULING MILESTONES

No public hearings are involved. After a 60-day review of the application by the Solid Waste Division, if the application is complete, a temporary permit is given allowing construction to begin. After construction completion, a final field inspection is conducted, and upon approval, a final permit is issued.

PERMIT APPLICATION LEAD TIME

60 days.

OIL SHALE PERMIT

PERMIT TITLE Construction and Operating Permit for New or Modification to Existing Facility

JURISDICTION Wyoming

LEGAL CITATION Wyoming Environmental Quality Act, Sections 35-502.10 et. seq. Air Quality Standards and Regulations, Section 21.

RESPONSIBLE AGENCY/CONTACT

Randolph Wood, Administrator
Wyoming Department of Environmental Quality
Air Quality Division
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7391

ABSTRACT

Application must be made by any person planning to construct a new installation or to modify an existing installation that may be a direct or indirect source of air pollution. This includes any installation of air cleaning devices to control emission of air contaminants. The permit is required before construction. Information required includes an impact analysis, potential emission rates, size of facility, location, etc.

Forms are available from the Air Quality Division with guidelines that pertain specifically to surface mining. The Division encourages prospective applicants to meet with them before filing.

After startup, a facility has 120 days to obtain an operating permit. During that time, the facility must show that it is in compliance with all air quality emission standards.

SCHEDULING MILESTONES

The Division has 30 days to review form for completeness, followed by a 60-day review. At that time, the Division will announce its decision in public notice and allow 30 days for public comment. Based upon public comment, a final decision may or may not be made.

PERMIT APPLICATION LEAD TIME At least 120 days for construction permit, followed by 120 days after startup for operating permit.

OIL SHALE PERMIT

PERMIT TITLE

Exploration Permit, License to Explore

JURISDICTION

Wyoming

LEGAL CITATION

WSA 35-11-405 and 406

RESPONSIBLE AGENCY/CONTACT

Walter Ackerman, Administrator
Wyoming Department of Environmental Quality
Land Quality Division
Hathaway Building
Cheyenne, Wyoming 82002
(307) 777-7756

ABSTRACT

When conducting an exploration program, an exploration permit is required. When drilling, a drilling program and plan must be submitted for approval, along with a minimum $10,000 bond.

SCHEDULING MILESTONES

None.

PERMIT APPLICATION LEAD TIME

1 week.

OIL SHALE PERMIT

PERMIT TITLE

Industrial Zone Change

JURISDICTION

Sweetwater County

LEGAL CITATION

Sweetwater County Zoning Resolution, Adopted August 8, 1972

RESPONSIBLE AGENCY/CONTACT

Dennis Watt, Planning Director
Sweetwater County Planning Department
P. O. Box 791
Green River, Wyoming 82935
(307) 875-2611

ABSTRACT

If a change in zoning requirements is necessary, a Petition for a Zone Change and a Zoning Permit Application must be filed. The information needed on these forms includes a legal description, reason for requesting the change, a map of the property and adjacent properties, and a listing of all owners of the property and all adjacent property owners. The zoning permit grants one or a combination of (1) construction and alteration, (2) use, (3) certificate of occupancy, and (4) temporary use.

SCHEDULING MILESTONES

Two public hearings are required; normally, each require 30 days notice. Sweetwater County, however, puts notice in paper for both hearings simultaneously with different hearing dates. One hearing is for the Statutory Planning and Zoning Commission, and one is for the Board of County Commissioners.

PERMIT APPLICATION LEAD TIME

Maximum 50 days.

OIL SHALE PERMIT

PERMIT TITLE

Conditional Permit

JURISDICTION

Sweetwater County

LEGAL CITATION

Sweetwater County Zoning Resolution, August 1972

RESPONSIBLE AGENCY/CONTACT

Dennis Watt, Planning Director
Sweetwater County Planning Department
P. O. Box 791
Green River, Wyoming 82935
(307) 875-2611 ext. 270

ABSTRACT

A conditional permit would be necessary if the oil shale activity involved any of the following: explosives manufacture or storage, above-ground storage of flammable liquids or gases exceeding 5,000 gal at one site, or the manufacture or storage of poisonous or toxic materials recognized as dangerous to animals and/or human beings.

This conditional permit would normally be issued in conjunction with the consideration of the requested zone change. Special conditions of Sweetwater County may be imposed. There are no forms utilized, but these conditions are noted on the application for zoning permit.

SCHEDULING MILESTONES

In conjunction with zone change.

PERMIT APPLICATION LEAD TIME

In conjunction with zone change.

OIL SHALE PERMIT

PERMIT TITLE

Mineral Extraction

JURISDICTION

Sweetwater County

LEGAL CITATION

None.

RESPONSIBLE AGENCY/CONTACT

Dennis Watt, Planning Director
Sweetwater County Planning Department
P. O. Box 791
Green River, Wyoming 82935
(307) 875-2611 ext. 270

ABSTRACT

Specific revisions are proposed for mineral extraction industries, but these have not been formalized or adopted.

SCHEDULING MILESTONES

None.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE Rights-of-Way Approvals	**JURISDICTION** Sweetwater County

LEGAL CITATION

No citation

RESPONSIBLE AGENCY/CONTACT

Sweetwater County Engineer
P. O. Box 632
Green River, Wyoming 82935
(307) 875-2611

ABSTRACT

Approvals for pipeline or other right-of-way crossings and for proposed roads didicated for public use are administered by the Office of the County Engineer. Normal procedure is for the applicant to forward a letter detailing his request for review to the County Engineer.

After this review, the County Engineer forwards his recommendations with the applicant's letter to the Sweetwater County Board of Commissioners for their formal approval.

SCHEDULING MILESTONES

Depends on complexity of request.

PERMIT APPLICATION LEAD TIME

Depends on situation.

OIL SHALE PERMIT

PERMIT TITLE

Solid Waste Disposal

JURISDICTION

Sweetwater County

LEGAL CITATION

See State of Wyoming Solid Waste Management Rules and Regulations.

RESPONSIBLE AGENCY/CONTACT

Rock Springs-Sweetwater County Solid
Waste District No. 1 Board
Mr. Fermelia, Sweetwater County Engineer
P. O. Box 632
Green River, Wyoming 82935
(307) 362-7519

ABSTRACT

The requirements for Sweetwater County are the State of Wyoming regulations. No separate county regulations are required.

SCHEDULING MILESTONES

Not applicable.

PERMIT APPLICATION LEAD TIME

Not applicable.

OIL SHALE PERMIT

PERMIT TITLE

Rezoning Permit

JURISDICTION

Rio Blanco County

LEGAL CITATION

Rio Blanco County Ordinance 317.1 et. seq.

RESPONSIBLE AGENCY/CONTACT

Glen Payne, County Planner
Rio Blanco County Planning Department
P. O. Box 599
Meeker, Colorado 81641
(303) 878-5081

ABSTRACT

Application for an amendment to the ordinance is to be made on a form provided by the Planning Commission and is to contain the following information: (a) description of land areas to be rezoned and requested new classification, along with a sketch to scale showing boundries of area requested to be rezoned, along with the existing zoning on all adjacent sides of the area; (b) a statement of justification for the rezoning; (c) description and sketches of buildings or uses proposed is rezoning is granted, along with a description of uses within 200 ft of the boundary of the proposed areas of change, in all directions, and the effect of the proposed use upon the adjacent areas; (d) time schedule for any contemplated new construction or uses; and (e) justification for any new business or industrial zoning.

SCHEDULING MILESTONES

Applications are submitted to the Director of the Planning Commission, who may hold any necessary hearings. Within 30 days after receipt, a recommendation will be made to the County Commissioners for approval, disapproval, or for an alternate proposal. At least 30 days notice must be given in a local newspaper before the hearing.

PERMIT APPLICATION LEAD TIME

At least 60 to 90 days.

OIL SHALE PERMIT

PERMIT TITLE

Temporary Use Permit

JURISDICTION

Rio Blanco County

LEGAL CITATION

Rio Blanco County Ordinances 306.0 et. seq.

RESPONSIBLE AGENCY/CONTACT

Glen Payne, County Planner
Rio Blanco County Planning Department
Meeker, Colorado 81641
(303) 878-5081

ABSTRACT

Upon application to the Zoning Enforcement Officer, a temporary use permit may be issued for the construction of an office, incidental to construction of other facilities. The permit is applicable to all Rio Blanco County zones for a period of up to 40 months. Failure to terminate such temporary use by the specified time shall be considered a misdemeanor and is punishable under section 314.0 of the Rio Blanco County ordinances, which dictate the powers of the Board of County Commissioners.

SCHEDULING MILESTONES

Application must be made to the Director of the Board of County Commissioners stating the nature of the proposed use. This would most likely be made in conjunction with the permit for a rezoning or a conditional use.

PERMIT APPLICATION LEAD TIME

Approximately 30 days.

OIL SHALE PERMIT

PERMIT TITLE

Conditional Use Permit

JURISDICTION

Rio Blanco County

LEGAL CITATION

Rio Blanco County Ordinances 305.1 et. seq.

RESPONSIBLE AGENCY/CONTACT

Glen Payne, County Planner
Rio Blanco County Planning Department
P. O. Box 599
Meeker, Colorado 81641
(303) 878-5081

ABSTRACT

Conditional uses described under section 305.2 are in part pertinent to mining applications. Some of the conditions are outlined as follows: (a) water must be kept out of underground mining workings, and facilities must be designed for this hazard; (b) disturbance to the surface of the ground shall be minor and limited to air shafts appropriate and necessary to the underground workings; (c) as new mining techniques or techniques for refining minerals in place are of an experimental nature, zoning changes rather than conditional use permits are appropriate, unless it can be shown that surface efforts are virtually impossible; and (d) mineral research sites are considered conditional provided that no permanent structures are built and provided that operatons will not exceed a period of 2 years.

Other conditions are also discussed under the conditional use provisions. The main goal is that the use should not scar the land and soil or leave such effects as denuded slopes, uncovered soil piles, or unguarded holes or pits. Surface mining is covered under other requirements.

SCHEDULING MILESTONES

After the Planning Department is satisfied that the application has been properly filled out, the Board of County Commissioners shall, in public hearing, after 30 days of public notice, take action on the recommendations of the Planning Commission. The application is in two parts: Part I is to be accepted by the Department, and then Part II is to be mutually reviewed and filled out with the aid of the Planning Department.

PERMIT APPLICATION LEAD TIME

Depends on extent of circumstances. Minimum time, 30 to 60 days.

OIL SHALE PERMIT

PERMIT TITLE

Building Permit

JURISDICTION

Rio Blanco County

LEGAL CITATION

Rio Blanco County Building Code, Chapter 500

RESPONSIBLE AGENCY/CONTACT

Glen Payne, County Planner
Rio Blanco County Planning Department
P. O. Box 599
Meeker, Colorado 81641
(303) 878-5081

ABSTRACT

A building permit is required for the construction of new buildings, the addition, alteration, repair, or removal of an existing building, or the movement of a building to another location. Separate permits are required for electrical, plumbing, heating, ventilation, or air conditioning.

The permit is null and void if work or construction authorized is not commenced within 120 days, or if construction or work is suspended or abandoned for a period of 120 days at any time after work is commenced.

A permit fee is required and is dependent on the assessed valuation of the building according to the fee schedule listed in section 504. On industrial and commercial buildings, an additional 65 percent fee is attached as a plan check fee.

SCHEDULING MILESTONES

Filing of a one-page building permit application.

PERMIT APPLICATION LEAD TIME

Approximately 30 days.

OIL SHALE PERMIT

PERMIT TITLE

Special Use Permit

JURISDICTION

Rio Blanco County

LEGAL CITATION

Rio Blanco County Ordinance 305.2 as amended (1974) and 1977 section 1000 et. seq.

RESPONSIBLE AGENCY/CONTACT

Glen Payne, County Planner
Rio Blanco County Planning Department
P. O. Box 599
Meeker, Colorado 81641
(303) 878-5081

ABSTRACT

The Special Use Permit provides for mining operations, open mining, and prospecting on land within the county that is zoned A (agricultural), H-I (heavy industrial), and O (open district), upon approval by the Board of County Commissioners. An impact analysis statement will be required with the application unless specifically exempt by the Board of County Commissioners. The statement shall include such information as short and long-term description of impacts, mitigating measures, and alternatives to the proposed action; it is in essence a small EIS. Detailed requirements include a mining plan, water, wildlife, revegetation actions, air, water, and waste problems expected and the solutions to these problems.

SCHEDULING MILESTONES

The Planning Department will review the application for completeness of information. Public hearing is held after a 30-day public notice by the Board of County Commissioners. In determining completeness of application, the Planning Department may hold one or more special sessions to review the application.

PERMIT APPLICATION LEAD TIME

Depends on situation.

OIL SHALE PERMIT

PERMIT TITLE

Sewage Disposal

JURISDICTION

Rio Blanco County

LEGAL CITATION

Rio Blanco County Ordinances, 1974 Chapter 800 Section 803.3

RESPONSIBLE AGENCY/CONTACT

Glen Payne, County Planner
Rio Blanco County Planning Department
P. O. Box 599
Meeker, Colorado 81641
(303) 878-5081

ABSTRACT

Before commencing construction, any person who wishes to install, alter, or repair a sewage disposal system must obtain a permit from the Health Officer. The permit asks for information pertinent to the location of the facility and characteristics of the water, soil, and groundwater of the area.

This permit is only for systems of less that 2,000 gal of sewage/day. In the case of any system with a design capacity over 2,000 gal/day, or which discharges into State waters, or which is designed to serve 20 or more persons per day, the County Planning Department may give its conditional approval or may disapprove the application. Thereafter, the application, with the Department's recommendation, shall be forwarded to the Water Quality Control Commisiion for its review.

SCHEDULING MILESTONES

A Registered Professional Engineer acting on behalf of the Department shall determine the type or types of disposal systems suitable for the property.

PERMIT APPLICATION LEAD TIME

Depends on size of system.

OIL SHALE PERMIT

PERMIT TITLE

Solid Waste Disposal Permit

JURISDICTION

Rio Blanco County

LEGAL CITATION

None

RESPONSIBLE AGENCY/CONTACT

Glen Payne, County Planner
Rio Blanco County Planning Department
P. O. Box 599
Meeker, Colorado 81641
(303) 878-5081

ABSTRACT

Industry's plans for solid waste disposal submitted to the State are reviewed by a county-selected engineering firm for completeness and accuracy. Industry is allowed to select their own disposal site upon approval of the engineers, the State, and county officials and residents. A public hearing at the county level is required. No formal requirements or regulations exist currently at the county level.

SCHEDULING MILESTONES

Depends on extent of wastes and whether or not they involve hazardous materials.

PERMIT APPLICATION LEAD TIME

Depends on materials.

OIL SHALE PERMIT

PERMIT TITLE

Conditional Use Permit

JURISDICTION

Garfield County

LEGAL CITATION

Garfield County Zoning Resolution Sections 4.03 and 7.02

RESPONSIBLE AGENCY/CONTACT

Ray Baldwin, Planning Director
Gafield County Planning Department
2014 Blake Avenue
Glenwood Springs, Colorado 81601
(303) 945-8212

ABSTRACT

The Conditional Use Permit applies to, but is not limited to, the following: (a) utilities that are adequate to provide water and sanitation service based on accepted engineering standards and approved by the Environmental Health Officer and the Colorado State Department of Health and that are either in place or to be constructed in conjunction with the proposed use; (b) industrial operations, including extraction, processing, water impoundments, and mineral waste disposal; (c) mobile home as an accessory to a working operation; (d) aircraft landing; (e) street improvements adequate to accommodate traffic volume generated by the proposed use and to provide safe and convenient access; and (f) design of the proposed use to minimize impact on and from adjacent uses of land.

In addition to this permit, an applicant for a permit for industrial operations is required to submit to the Building Official two copies of an impact statement on the proposed use, prescribing its location, scope, design, and construction schedule, including explanation of operational characteristics. The statement shall show that the use shall be designed and operated in compliance with all applicable laws and regulations of the County, State, and Federal governments, and will not have significant adverse impacts. Satisfactory land rehabilitation plans for the affected areas must also be submitted.

SCHEDULING MILESTONES

If the industrial operations section applies and an impact statement is required, then the County Commissioners have 30 days to notify the Building Official of their decision. A request for additional information may be made before the 30-day limit. The County Commissioners shall then have an additional 30 days for review and subsequent decision.

PERMIT APPLICATION LEAD TIME

At least 60 to 90 days.

OIL SHALE PERMIT

PERMIT TITLE

Special Use Permit

JURISDICTION

Garfield County

LEGAL CITATION

Garfield County Zoning Resolution Sections 4.03 and 7.03

RESPONSIBLE AGENCY/CONTACT

Ray Baldwin, Planning Director
Garfield County Planning Department
2014 Blake Avenue
Glenwood Springs, Colorado 81601
(303) 945-8212

ABSTRACT

Application and requirements for a Special Use Permit are very similar to those for the Conditional Use Permit. Applicants should seek assistance of the Director in determining necessary filing requirements. Basically, the application for a special use permit consists of: (a) supporting information, plans, letters of approval from responsible agencies, and other information to satisfy requirements listed under Conditional and Special Uses in Section 4.03 et seq. of the regulations; (b) a vicinity map drawn to scale depicting the subject property, location of roads providing access to the subject property, location and use of buildings and structures and adjacent lots, and the names of owners of record of such lots, and (c) a letter to the County Commissioners from the applicant explaining in detail the nature and character of the special use requested.

SCHEDULING MILESTONES

The County Commissioners shall decide no later than 30 days following the receipt of the application and the recommendation of the Building Official, and if no negative public comments are received resulting from public hearing. The County Commissioners shall approve or deny the application and notify the applicant of its decision within 15 days following the public hearing.

PERMIT APPLICATION LEAD TIME

At least 60 days.

OIL SHALE PERMIT

PERMIT TITLE

Sewage Disposal System

JURISDICTION

Garfield County

LEGAL CITATION

Garfield County Sewage Disposal Regulations

RESPONSIBLE AGENCY/CONTACT

Ray Baldwin, Planning Director
Garfield County Planning Department
2014 Blake Avenue
Glenwood Springs, Colorado 81601
(303) 945-8212

ABSTRACT

These regulations are designed to comply with the guidelines as adopted by the Colorado Board of Health pursuant to 66-44-4, C.R.S., 1963.

Before commencing construction, any person who wishes to install, alter, or repair an individual sewage disposal system in Garfield County is required to obtain a permit from the Health Officer. The permit shall contain the following information: (a) legal description of the property, (b) owners(s), agents, and contractors names, addresses, and phone numbers, (c) plot plan and size area, (d) type of buildings, water supply, and soil or soil classification, (e) soil percolation or hydraulic conductivity tests when necessary to the design of the disposal system, (f) location of bedrock and groundwater table, (g) type and design of the disposal system, and (h) other pertinent information, as may be required by the Health Officer.

After receiving an application form, a Registered Professional Sanitarian or Registered Engineer shall have the perogative to visit the applicant's property to make a preliminary investigation on behalf of the department.

Any system that has a design capacity over 2,000 gal/day, or that discharges into State waters, or that is designed to serve more than 20 persons/day may subject to approval by the State Water Quality Control Commission.

SCHEDULING MILESTONES

Depends on size of facility and whether situation involves county or State approval.

PERMIT APPLICATION LEAD TIME

Depends on situation.

OIL SHALE PERMIT

PERMIT TITLE

Solid Waste Disposal

JURISDICTION

Garfield County

LEGAL CITATION

None

RESPONSIBLE AGENCY/CONTACT

Ed Feld, Wastes Division
Garfield County Planning Department
2014 Blake Avenue
Glenwood Springs, Colorado 81601
(303) 945-8212

ABSTRACT

A solid waste site designation from commissioners is required with a $25 charge. A form is available from the Wastes Division. Information to be submitted includes proposed work, quantity of wastes, duration of dumping, proximity to streams and groundwater sources, etc.

SCHEDULING MILESTONES

No public hearing is required. Processing time depends on situation.

PERMIT APPLICATION LEAD TIME

Depends on situation.

OIL SHALE PERMIT

PERMIT TITLE

Installation of Utilities in Public Right-of-Ways

JURISDICTION

Garfield County

LEGAL CITATION

None

RESPONSIBLE AGENCY/CONTACT

Leonard Bowlby
Garfield County Planning Department
2014 Blake Avenue
Glenwood Springs, Colorado 81601
(303) 945-8212

ABSTRACT

Application form is available for a construction for installation of utilities in public right-of-ways. Needed for the form is location and description of work. Applicant will be responsible for repairs and maintanence of areas for 1 year.

SCHEDULING MILESTONES

No public hearing is involved. The final location will be mutually agreed on by applicant and Board of Commissioners in accordance with details and specifications shown on construction plans.

PERMIT APPLICATION LEAD TIME

Depends on situation.

OIL SHALE PERMIT

PERMIT TITLE

Driveway Permit Across County Roads

JURISDICTION

Garfield County

LEGAL CITATION

None

RESPONSIBLE AGENCY/CONTACT

Leonard Bowlby
Garfield County Planning Department
2014 Blake Avenue
Glenwood Springs, Colorado 81601
(303) 945-8212

ABSTRACT

A driveway approach is that portion of the highway right-of-way between the pavement edge and the property line that is designed and used for the interchange of traffic between the roadway pavement and the abutting property. Any driveways and approaches must be paid for and maintained for 1 year by the applicant. This applies only to county roads.

SCHEDULING MILESTONES

Depends on situation. No public hearing is required unless the request is unusual.

PERMIT APPLICATION LEAD TIME

Depends on situation.

OIL SHALE PERMIT

PERMIT TITLE

Recreation Forest and Mining Zone
(RF&M) - definition and control

JURISDICTION

Uintah County

LEGAL CITATION

Uintah County Zoning Ordinance No. 3-71 Section 02.0871 - 02.0878

RESPONSIBLE AGENCY/CONTACT

Jess Miller, Administrator
Uintah County Planning & Zoning Board
220 South 500 Street
Vernal, Utah 84078
(801) 789-4302

ABSTRACT

The Recreation Forest and Mining zone contains some deeply buried oil shale in the facia interbedding of the Green River and Wasatch formations in the north-west portion of the county. The zone is generally mountainous in an unincorporated area. It also has grazing lands, ranches, resorts, outdoor recreational facilities, and mines and related facilities. The following are some of the uses permitted in the zone:

(1) Wells, mining, extraction, processing and reduction of minerals, and buildings, structures, and related facilities.

(2) Reservoirs, ponds, dams, power plants, transmission lines, and substation, water pumping plants and pipelines, and public utility buildings and structures.

(3) Water supply and sewage disposal in compliance with the Department of Health Requirements (State).

SCHEDULING MILESTONES

None.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE

Mining and Grazing Zone (M&G-1)
Definition and Control

JURISDICTION

Uintah County

LEGAL CITATION

Uintah County Zoning Ordinance No. 3-71 Section 02.0860 - 02.0863

RESPONSIBLE AGENCY/CONTACT

Jess Miller, Administrator
Uintah County Planning and Zoning Board
220 South 500 East
Vernal, Utah 84078
(801) 789-4382

ABSTRACT

The mining and grazing zone encompasses most of the oil shale area suitable for the near future development. The zone is characterized by large tracts of desert and open-range land, with an occasional mine, cabin, dwelling, and/or corral incidental to livestock operations. The following are permitted in this zone:

(1) Open-pit mines, mine waste dumps, underground mines, and buildings and structures associated with mines and mine dumps.

(2) Storage and use of explosives, provided all activities are located at least 300 ft from a public street or building.

(3) Mineral reduction and processing plants.

(4) Sewerage treatment plants subject to approval by the Board of Adjustment and State Department of Health.

(5) Reservoirs, dams, sumping plants, and water facilities.

(6) Other uses ruled by the Board of Adjustments to be harmonious with the objectives and characteristics of the mining and grazing zone.

SCHEDULING MILESTONES

None.

PERMIT APPLICATION LEAD TIME

None.

OIL SHALE PERMIT

PERMIT TITLE County Requirements in Addition to the Mining and Grazing (M&G-1) and Recreation Forest and Mining (RF&M) Zoning Requirements

JURISDICTION

Uintah County

LEGAL CITATION

Uintah County Zoning Ordinance 3-71

RESPONSIBLE AGENCY/CONTACT

Jess Miller, Administrator
Uintah County Planning and Zoning Board
220 South 500 East
Vernal, Utah 84078
(801) 789-4382

ABSTRACT

The county requires building permits, business licenses, and water and sewer facilities to be approved by the State Board of Health. Site selection requirements and approvals are required by the State Site Selection Committee in Conjunction with the developer. The final site will be chosen from an alternative list approved by the Committee.

Mining permits and plans for mined land reclamation, including dumps, are issued by the State Division of Oil, Gas, and Mining, except where coal is involved on Federal lands.

Air quality in most of the area zoned M&G-1 is unclassified and would require a State Air Quality Committee and or a Board of Health discharge permit.

SCHEDULING MILESTONES

See State requirements.

PERMIT APPLICATION LEAD TIME

None.

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